NATURE-STUDY

FREDERICK L. HOLTZ

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NATURE-STUDY

A MANUAL FOR TEACHERS AND STUDENTS

BY

FREDERICK L. HOLTZ, A.M.

Head of Department of Nature-Study, Brooklyn Training School for Teachers, New York City. Formerly Head of Department of Biology and Nature-Study, State Normal School, Mankato, Minn.

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PREFACE

This book is designed as an aid and guide to the practical teacher, and as a text-book in methods of nature-study for normal and training schools.

Part I is devoted to a discussion of underlying principles and methods. A just appreciation of the purpose of nature-study and a good technique in teaching are as essential as a knowledge of subject-matter, especially in a subject like this, which must be taught without text-books.

Part II contains appropriate subject-matter of a biological nature, and practical hints and suggestions on the collection and care of material, and the presentation of lessons. I have, however, avoided working out complete lesson-plans for the teacher, believing it far better to allow her to adapt the subject-matter herself to her own conditions, and to give an opportunity for originality.

Emphasis is placed on the teaching of life-histories, life-habits, functions and processes, and not on mere structure study. Of chief importance also in nature-study are the adaptations to function and environment, the interrelations of plants and animals, their economic aspects, and practical bearing on human life.

Part III consists of a course of nature-study for the eight grades. It represents a serious effort to organize and im-

prove the present-day courses in this subject, and is based upon an exhaustive, comparative examination of the curricula at the principal nature-study centres in this country. The requirements of both city and rural schools are considered, and enough material is given to permit a rich treatment in either case.

In the Appendix is a carefully selected, classified, and annotated list of reference books and nature readers.

A few illustrations have been kindly loaned, for which credit is given in each case. Mrs. Henry Parsons, Director of the Children's Farm School, New York City, furnished the photograph for figure 97.

I acknowledge my indebtedness and express my gratitude to all who have assisted or encouraged me in the preparation of this book, particularly to my wife; to my former colleagues, Mr. John A. Hancock and Miss Martha V. Collins, of the State Normal School, Mankato, Minn.; to Dr. Stuart H. Rowe, of the Training School for Teachers, Brooklyn, N.Y.; and to Mr. Geo. P. Englehardt, Children's Museum, Brooklyn, N. Y.

FREDERICK L. HOLTZ.

Training School for Teachers, Brooklyn, N. Y.
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PART I

GENERAL PRINCIPLES OF NATURE-STUDY

CHAPTER I

THE MOTIVE

THERE are two powerful instincts inborn in every child that may be utilized by the school in directing his efforts. These are innate curiosity and the social instinct. Through the social instinct the child identifies himself with those about him and feels his relationship to them. All his acts and thoughts have more or less a social bearing. He is greatly influenced, often compelled, in his mental development by the judgment of his associates, by public opinion. He wishes to conform to society. In its broad application this instinct leads not only to the wish to know and do what others know and do, but to the desire to harmonize with society and sympathize with it, to be useful and to serve it.

Every age is reflected in its schools. The ideals of the school are largely the ideals of contemporary society. The practical and scientific character of our age has necessarily influenced education. So we find that the physical basis and the scientific aspects of human society, and the industrial conditions and processes demand and attract the attention of the schools. And one function of the school is to fit the child for the social and natural environment in which he is placed. This is often construed to apply simply as a preparation for adult life. But the child leads a present life of his own, during which he should

be in an intelligent relation with man and nature, just as much as in adult years.

The child wants to know about the social and industrial life around him, and the origin, working, and use of the manifold devices and processes on every hand. He not only wants to know these things for himself, but that he may explain them to others; to entertain, to be helpful and useful to others. Later comes the desire to share in the world's work as a self-supporting member of society.

When studies are presented with this social consideration the pupils appreciate the motive themselves—perhaps not fully—but enough to make them feel it worth their while to study. A real interest is infused into their work, a real object to be gained is perceived. They feel that they are studying not merely for the sake of learning, but for the bearing it has upon their own lives.

The reality of the studies and their connection with life are made very evident when they are drawn from the child's immediate home, the surrounding fields and hills, the schoolhouse itself, and the industries of his community. Household articles, the kitchen processes, the hygienic measures of the school, the plants and animals of the garden, farm, and forest, the varied occupations of the community, and the innumerable machines and processes by which these are carried on—all claim attention and demand investigation. A study of the fundamental industries of man, especially in their primitive form, leading up to their present development, affords not only an intelligent grasp of the social industries, but gives an historic insight into their development which increases the social value of the information. Moreover, a rational basis is laid for the study of history and geography.

Geography proper furnishes many suggestions for nature lessons and also provides the social motive again. Numerous topics of human interest referred to in this subject can be explained by nature-study, and their bearing upon life emphasized. The two subjects should be closely correlated.

Manual training and domestic science, two other great socializing studies of the school, are dependent upon nature-study for many explanations of materials and methods. There is a need to know the properties of the materials and the way of making things. The value of nature-study in this case is apparent. Here the knowledge is recognized not as an end, but as a means to accomplish something to be desired. Simple biology, chemistry, and physics, thus correlated with manual training and domestic economy, are seen to have much to do with human affairs. The simple application of nature-study in this way in school leads to an appreciation of the scientific basis of our sanitary and economic methods of the home, school, and community, and our complex industrial life generally. By such a correlation these "making" subjects are enriched, and their intellectual content is increased.

Nature-study has a satisfactory *raison d'être* for the child, if presented in the manner suggested. The school life in a measure reflects the community life and enables him to live in that community intelligently.

But the child is interested in nature-study in another way. The social interest is, perhaps, the dominant one; but another more purely intellectual impulse prevails. This is the outcome of curiosity, wonder—and is the complement of the social interest in bringing him into right relationship with the world.

The child wonders about the objects and phenomena of nature; he is curious about them, perhaps for no reason except that they attract his attention. He feels that he must know what and why these things are, and this irrespective of any consideration of the usefulness or applicability of the knowledge to himself or to society. In much the same way the adult scientist craves a satisfying explanation of, or insight into, many facts of nature. I believe this powerful impulse should not be neglected in education, though it may be carried too far and lead to mere book learning, with a disregard for the fact that, in general, knowledge should be a means and not an end in itself. Nevertheless, this knowledge gained through mere curiosity, though not always practical, affords much satisfaction and pleasure. It is the basis for our æsthetic and spiritual view of nature. It creates a certain pleasant familiarity with nature, and on one's rambles in the park or in the country makes one feel *en rapport* with it. Through this curiosity we learn of many interesting and beautiful relations in the natural world. We find that a unity prevails and we discern a plan more or less clearly. In short, this impulse arising from curiosity finally places the individual in harmony with the natural world and adds in a great measure to general culture.

This harmonizing of man and nature is an essential element in education. It must not be forgotten, however, that much of this knowledge gained from curiosity or—to use another expression—in the search for truth may later be found to be of great, perhaps the highest, practical value. Through this everlasting spirit of inquiry many important facts and principles have been discovered, and the field of human vision widened.

The child should be allowed to investigate freely in nature whatever his interest suggests. This sympathy with birds, insects, plants, and even inanimate nature is one of the most desirable things he can get from nature-study. If nothing more it ought to make him happier in this wonderful and beautiful world.

If we utilize as we should these natural interests or innate impulses of the child, we have enough of stimulus or motive to vitalize nature-study.

CHAPTER II

THE EDUCATIONAL VALUE OF NATURE-STUDY

The child should be given such educational material as suits his childhood interests and needs. This does not mean to let him learn simply what he likes and in his own way. He may like what is not good for him. The experience and wisdom of his parents and teachers must be used in shaping his education. The child's and the adult's view of education need not be incompatible. The child should be so educated as to live as completely as possible his transient childhood years, but by the foresight and experience of his elders he may also receive discipline of mind and character, and be supplied with the knowledge necessary for adult life as well.

When the mind is applied to the study of natural objects and phenomena all its powers receive some discipline. In the first place there is the power of observation, perhaps not the highest faculty, and yet a very necessary and fundamental one. For through the power of perception we learn of things outside of ourselves. An infant devoid of this power could not develop mentally. But this is the first faculty exercised by the normal child. He begins in the cradle to observe things by touching, hearing, seeing, tasting, and smelling them. This is his first education. It is a well-known fact that any of these senses can be made keener and more accurate by practice. Contrariwise it is true that they become dulled

by disuse. Since the senses are the gateway for our knowledge of the outer world, it is necessary to train them well. We must learn to perceive things as they really are. Clear and truthful perceptions are the basis of sound thinking.

But observation should lead to thought. The mind should be receptive, should take in the newly observed facts and connect them with what is already known. That is, there should be what is pedagogically called apperception, as well as perception, in order to make intellectual progress, to increase the sum of individual knowledge.

Now, nature-study is especially suitable for stimulating and training the power of observation. There are hosts of animate and inanimate things to be observed and thought about. In such thinking there is something tangible and concrete. The object can be seen and handled, perhaps. Children are not mature enough for much abstract thinking. Hence object-study is more suitable for them. By a proper selection of material and proper guidance, the child may be made more observant of natural things around him, to his lasting benefit and pleasure.

In the education of our children we seem to neglect the hint that nature herself has given us. Before school-days begin education is chiefly through observation. The founders of the kindergarten taught that this method should be continued in the school, and not set aside by the use of books, as is so generally the case. Books have a very great value, but they give their information at second hand. A book tells what some one else thinks about something, and no reader of such a book can get as vivid or perfect a knowledge of the thing as had the author, who learned the fact first hand. "Seeing is believing" is a maxim full of truth. We should

keep up the spirit of personal observation and investigation. If this is not done the child is too apt to be satisfied with mere statements in books or by teachers, and too ready to accept another's opinion as his own. A little healthy scepticism in studying is a good thing, especially where one can find out for himself the actual facts. Nature-study aims to keep alive the inquiring spirit.

It has been said that the child is a young savage. This is true in several respects. Science tells us that an animal or a plant in its physical development passes in general through the stages through which the race to which it belongs has passed in its development. For example, in the embryology of the frog there is a stage that is like the fish—the tadpole stage. Other facts prove the origin of frogs from fish-like ancestors. Every frog repeats this fish-like stage.

It has become an educational maxim that the mental evolution of a child corresponds in a measure to the mental evolution of the race to which he belongs. That is, the child exhibits mental traits that were once characteristic of his race when in the primitive state. In pedagogy we hear this spoken of as the Culture Epoch Theory, and though it is not fully worked out in its applications, this theory is already useful in education. We cannot safely change the course of nature in the development of mind or body. It is better to take a suggestion from nature and to work with, rather than against, her.

A young child, though he may not show his savagery in cruelty, nevertheless shows his interests to be chiefly in objective things—in people, human activities, and natural objects. Children are proverbially inquisitive regarding natural objects. In childhood are formed the attachments

to pets. Boys are interested in hunting, fishing, and outdoor sports, and like to play Indians. Children also like birds and plants. Their nature-love seems to be instinctive, and is probably an inheritance from their savage, nature-loving ancestry.

Then let us give the child opportunity to taste nature as much as possible, and use this inherent interest to teach him about his natural environment. Repeat the old story. Teach him the good things he can use and enjoy and the bad things that he should avoid.

Mathematics gives the mind excellent training in abstract thinking and familiarizes the mind with logical processes. But nature-study also trains the reasoning powers. The reasoning afforded by science in general is not abstract, but more concrete and more like the reasoning of every-day life. In nature-study a child observes a number of facts, or a series of phenomena, and from them makes a generalization or conclusion. He learns the principle of cause and effect. He sees that things are not left to chance, but that the rule of cause and effect governs all action. He learns to apply this rule in other fields of thought, in literature, history, civics, politics, and personal conduct. The comparison and classification of natural objects give an excellent training in systematic thought. The derivation of laws from experiments or observations affords the best of practice in inductive reasoning, while deduction is employed in every application of these laws.

By imagination the facts once learned are recalled and brought into new relations. In this new relation they combine to form new ideas or to suggest new thoughts. By unrestricted exercise of the power of imagination mental prod-

ucts can be formed that have no counterpart in reality. The result may be pure fancy. Although this may be legitimate in literature and art, it has no place in science. In the search for truth the imagination should be watched lest it lead astray. In science-study there is abundant opportunity for the exercise and also, which is important, the control of the imagination. "Of all the powers of the mind it is certainly that which is most important in giving originality to the results of thought," say Hall and Smith.[1] "But in proportion to its value and activity is the difficulty of controlling its operations. The imagination is a good servant but a bad master. The opportunity which is offered in experimental science to test the results of imagination by comparison, again and again renewed, with the concrete materials with which it has been dealing, furnishes an unrivalled opportunity to practise and control it." While the above applies especially to the maturer study of the sciences it also applies in nature-study. Children love to theorize if given the chance, and they should be taught to check their imagination with the facts before them.

Many people cannot appreciate the value of mental training merely for the sake of sharpening the wits, and decry all education that cannot be applied directly to the earning of dollars and cents. "What is the *use* of such learning?" they ask. This is a practical generation, and education must meet the practical test of every-day life. If any subject has practical value it is natural science, for through it we become better acquainted with our environment. Man will never be free from the natural conditions that now affect his life. He will always need food, clothing, and shelter; he

[1] "Teaching of Physics and Chemistry," p. 11.

will need to make implements and tools to furnish these; he will want conveniences and pleasures above his animal needs; he will be subject to disease and physical accidents, and will need to prevent or remedy them. These stern necessities he can meet only if he knows how to do so. The better he understands the laws of nature, the better knowledge he has of the properties and uses of plants and animals and the products of nature, the better he can distinguish between the good and the bad natural agencies, so much better will he be able to live without cold, hunger, pain, and fear. As long as he acts in accordance with natural laws, all is well; but he is punished for the slightest transgressions. This is seen most obviously in the matter of hygiene. More people die through ignorance of the laws of health than are destroyed in wars.

CHAPTER III

THE ÆSTHETIC AND ETHICAL VALUE OF NATURE-STUDY

KNOWLEDGE is power. It is also pleasure or affords pleasure. Many students learn for the mere pleasure of learning. This is the case of the scientist who discovers the laws of nature or proves a theory, without a thought of their practical application. Even a child in the satisfaction of his curiosity has a similar feeling.

But we can get sweet and helpful pleasure also from the sensuous enjoyment of the beauty of nature's forms and colors, the songs of birds and the sound of running waters, the fragrance of the flowers and the smell of the earth and sea, the delicious flavor of fruit, the warmth of the genial sunshine, the touch of our feet on the ground, or the feel of the earth as we lie upon it. These pleasures of the senses, though not the higher kind, should not be neglected. Without them life would be much more matter-of-fact and uninteresting. Just as it is right to enjoy sensuously good music or the lines and coloring of a beautiful work of art, and as it is right to train the ear for music and the eye to discriminate beauty in art, just so is it right for us to enjoy nature through the senses, and to cultivate them so that we may enjoy more fully and intelligently. These animal sensations of the charms of nature add immensely to the pleasure of living, and, directly or indirectly, affect our views of life.

Nature-study has perhaps been the chief factor in the culture development of the human race. At first man was the fearful slave of nature, seeking a precarious existence, struggling blindly with natural forces. Then he became nature's pupil. By observation of the creatures about him and by personal experience he learned to adapt himself better to his environment. The more he learned the better fitted he became for life, and the more his mind expanded. Simple inventions of tools, the domestication of animals, and the cultivation of plants soon made the slave the master, so that to-day man takes advantage of his environment, utilizes the resources of nature, and even directs her course very largely for his own ends.

As children of to-day personify, so primitive man attempted to explain the wonderful phenomena of nature about him by personifying the mysterious forces that so powerfully affected his life. Thus mythology and religion had their origin. The ideas awakened by, and the pleasures derived from, nature have had very much to do with the development of poetry, music, painting, and sculpture.

Our relations with nature are of long standing. The dependence of our forefathers on the forest, the sea, the wild animals, and the elements has been deeply impressed upon the human race, so that even many generations of artificial urban life have not entirely obliterated our nature instinct,—the impulse that leads us back to nature. In many this instinct is very pronounced and needs but little encouragement. In others it is less developed and may entirely disappear from persistent disuse. It should, however, be developed into the habit of active and discriminating observation and the correct interpretation of nature.

Children generally display this nature instinct more than adults, though not as much as many adults. The child likes the pretty colored insects, leaves, and birds. He likes to play in the earth, and to frolic with pets and wild animals. The sympathy for pets and, through them, for other creatures is one of the finest things we can teach through nature-study. The child is greatly interested in the animals of the farm, in their uses and care. He likes flowers and fruit, and can be readily taught to care for growing plants. There is an æsthetic and a moral as well as an educational element in the cultivation of potted plants, trees, gardens, etc. Children love to roam about in the fields and forests and enjoy the mystery of their numberless discoveries. They like to be on the water, or in it. They like to fish, hunt, and camp. They like to play the primitive life of the Indian or the pioneer.

Later, as imagination and knowledge develop, comes the enjoyment of scenery, the landscape, the sea, and sky effects; later, also, the appreciation of the beautiful adaptations and interrelations in nature. Then, too, come the perception and admiration of natural forces and the laws according to which they act, and the attempts to see a unity and a guidance in the universe. Enjoyment of nature becomes more and more conscious. Personal applications are made of nature's principles. We try to fit into the world-scheme —and our religious and philosophical interests develop.

Much may be done to cultivate in children a love for nature. Bring the child often in contact with nature, and let her silent influences work. Let him be taken on field trips to enjoy the beauty of the flowers, the birds, etc. Point out these things to the children who fail to see for themselves.

Call attention to the changing beauty of the landscape. Let the children tell what they enjoy in it. Point out more, if they are old enough to appreciate it. Show them the play of light and shade, the harmony of the colors, the subdued hues, the neutral tints of forest and meadow, of mountain and fading perspectives. The sky, with its varying cloud effects and changing light and color from sunrise to sunset, in calm and in storm, should appeal to all. The teacher should be careful not to go into rhapsodies over these beautiful phenomena, but should simply seek to remind the child of them, and to point out those features missed by the children themselves. It is well to remember in this appreciation of nature that much depends upon the attitude and mood of the observer. The teacher should try first to bring herself and her pupils into the proper receptive or sympathetic attitude.

Poets of all ages have felt the influences of nature, and have interpreted it for others, or have shown them its grandeur, beauty, and mystery. Their works are especially enjoyed by those who love nature themselves and have had similar experiences. Others learn from them what to look for and enjoy.

There is a great wealth of prose and poetry that may be used judiciously in developing in children an appreciative spirit toward nature. Thus, occasionally, interest may be aroused in a nature lesson by first reading some selection suitable for the occasion. Or, perhaps better, after the nature lesson such selections used in the reading lesson would bring out a human aspect, or an æsthetic or spiritual element. The poems of Wordsworth, Bryant, Longfellow, Celia Thaxter, and F. D. Sherman, and the prose of Emerson,

Warner, Burroughs, Torrey, VanDyke, E. T. Seton, W. J. Long, and many others, if read by the pupils cannot fail to develop somewhat the appreciation of nature.

The Ethical and Spiritual Side of Nature-Study

There is an ethical element in nature-study. The search for and recognition of truth in nature-study has a definite moral tendency. All great scientists have a high ideal of truth. Nature-study, by constantly checking the thought by the actual facts, tends toward intellectual honesty. Again, the rule of cause and effect exemplified so concretely in nature-study, when applied to personal and social relations, tends strongly toward moral improvement.

It is customary to teach children about animal wisdom, providence, care and love for the young, etc. These things, no doubt, are interesting to children as reflecting their own home life, and some moral benefit is derived therefrom; but one of the best things they get from nature-study is a sympathy and love for the lower animals. The care for pets is good nature-study and also good moral training, for it teaches us to consider the wants of these animals. Children, however, should be taught to be kind also to the birds, the squirrels, frogs and toads, instead of cruel as they so often are. They should be taught to recognize the right of all harmless creatures to live. They should be made to feel that we and the animals are kin.

The raising of plants and the cultivation of a garden also may teach regularity, watchfulness, patience, and persistence. Lovers of plants show an almost affectionate interest in their development. Flower culture develops a gentleness of spirit in the children who practise it. Many believe a boy cannot

become a vagabond and criminal if he has been taught to love the cultivation of plants.

The study of nature has another very important moral aspect. Ignorance is a kind of immorality, especially where people ought to, or could, have known better. Through ignorance and, perhaps, absolute disregard for simple natural laws there result much loss and trouble.

Farmers try to raise crops and cattle on unsuitable land and in unsuitable climate, or they fail because of improper or ignorant treatment. A vast amount of fuel is lost in smoke, in radiation, and in friction, which should be saved. Through improvident and ruthless lumbering methods, our country is being denuded of its forests, and our timber supply is being exhausted. Through the wanton and cruel destruction of beneficial birds, insect pests are multiplying to the injury of our gardens and fields. There is a waste in the household economy in the choice and the cooking of food. Devastating fires and appalling accidents occur with great consequent loss of life and property. In all these cases a proper study of, and regard for, the laws of nature would do much to prevent or remedy the evil.

Sanitation and disease are matters of such social concern that in every enlightened community general laws are passed respecting them. The individual must submit to society in these matters, for he may spread disease far and wide. So we have quarantine and sanitary laws by which contagious diseases are kept in check. Much disease is caused through pure ignorance. Bacteria are allowed to develop among filth, and to contaminate food, to infect persons, and to cause epidemic disease. In India pilgrims, some of them diseased, perhaps with cholera, come to bathe in and drink of the water of

the sacred pools, and then go home carrying with them the germs of disease to many regions. A scourge of cholera is the result. And what is the cause of all this? Pure ignorance. Such ignorance in an enlightened country is not only wrong, but immoral. Statutes even make it criminal to violate the rules of the boards of health. All this goes to show that there is a great social interest in nature-study that will teach people how to live a self-supporting, safe, and healthy life. For people who cannot do this become public charges or menace the public welfare.

The study of the wonderful things of the world, their beautiful fitness for their existence and functions, the remarkable progressive tendency of all organic life, and the unity that prevails in it create admiration in the beholder and tend to his spiritual uplifting. He feels a greater reverence for the wonderful universe and its mysterious forces. He is compelled to think of the Why and the Wherefore of it all, and he must think of the Great First Cause.

The contemplation of nature, the works of God, naturally tends to make one believe in an all-planning and all-guiding Influence.

The all-pervading and controlling Force in nature is seen in the star, in the work of the elements, in the pearly nautilus, in the flower. If we knew the ultimate meaning of all or each we might have the key to existence. That is what Tennyson meant when he wrote

> Flower in the crannied wall,
> I pluck you out of the crannies;—
> Hold you here, root and all, in my hand,
> Little flower; but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is.

CHAPTER IV

STUDYING NATURE IN THE GRADES—HOW AND WHAT

THERE is no hard and fast rule for studying nature in the grades. It would be better not to have any set lessons at all, if the formal lessons only tired the children and destroyed their interest. This does not mean that a formal lesson in nature-study may not be highly interesting and inspiring in the hands of an able and enthusiastic teacher. It can, and more lasting results in the way of definite knowledge and training in thinking can be given by such formal lessons than by the informal.

A teacher of nature-study should ever be observant of nature, and should call the attention of the children to such things as they are prepared to grasp. If a teacher sees the first robin in spring, let her speak of it in school and ask the children to be on the watch. If she finds an interesting flower, a stone, or insect, let her show it to the pupils and tell them about it. This can often be done at recess or before or after school, or a few moments may be taken daily or occasionally in the general period for such informal observations of nature. In this way call attention to the changing pictures of the seasons, the return of the birds, the spring flowers, the brook, the insect life, the rain and the snow flake, the eclipse, the stars, etc. Name for the children the plants and the animals they see. Let them bring in "specimens" of all kinds and use

them as texts in nature lessons. In these informal lessons let the pupils talk as much as they can or will about the object.

In the primary grades the nature material is chiefly studied from a different motive than in the higher. Here its main purpose is to develop expression and to cultivate the observing powers. Oral and written language and art are largely taught with it. The informational side is mainly identification and getting introduced to nature. Structural details and functions should be minimized, though not entirely omitted. For these reasons the method of presenting nature lessons in these grades is much more informal than in upper grades. It is more conversational, and more spontaneous or unsolicited expression is expected from the children. Let them tell in their own way what they see or know about the object. Habits and uses appeal more to the little children than descriptions of structure and appearance. And, yet, enough for identification should be done with these.

As the children are allowed more freedom to express themselves, the plan of a lesson should not be so systematically carried out as would be the case in higher grades. The teacher will have to be governed largely by the turn taken by the interests of the children. Still, there can be considerable guidance in the observations, by asking questions or showing points. As the children get older more system can be demanded. Frequently things need not be studied with any formality whatever. Children gain a good deal by just looking at a fish in an aquarium, or a butterfly on a flower, without any directions or questions from the teacher. Many things on a field-trip may thus be observed in this very informal manner. Perhaps this is especially good where the beauty of nature is the chief item of interest. Sometimes

an object may simply be shown to the children, and a story, anecdote, or poem read or told by the teacher about it. Such informal methods are interesting variations of the usual method of presentation. In general, however, the half informal, conversational development method is better —the pupil as well as the teacher asking questions. As the children grow stronger the teacher should tell less and ask more. She should direct observation along more definite lines, and see more to the relations and the unity of the lesson.

A definite course of instruction, however, requires a little more system and formality, and so does the usual drill work. Hence, where the time can be afforded, and it should be everywhere, daily, semi-weekly, or weekly formal lessons should be given on nature subjects.[1]

In the regular lessons the development plan is generally followed. This method is the application of the rule: "Don't tell a child what he can find out for himself." A lesson should stimulate thought. The teacher by skilful questioning directs the attention of the child to the facts he can easily observe and then asks him to make his own conclusion. This method, known as the Development Method, is especially suitable for nature-study. In this we have, or should have, the actual object or phenomenon before the pupil. It is true that too many nature lessons, or so-called object lessons, are given without the object present.

The scientific method of study is: Do not take things for granted, but find out for yourself. This method trains pupils to think for themselves. Too much talking by the teacher allows the pupils' minds to lie idle and passive. Exercise strengthens them.

[1] See page 397 for course of study.

As a general rule pupils need not be told beforehand what a certain nature lesson is to be about, for it is generally studied in class and not before. The recitation is really a study period, and all the children should partake in the work. All should get the facts brought out. This will require more or less drill and summarizing, as in other lessons. Occasionally pupils may be asked to make certain preliminary observations which are to be utilized in the succeeding development lesson.

Nature-study requires no text-book for the pupils except the great book of nature herself. The lessons in school may, however, be supplemented with outside reading.

The Development Lesson

THE PREPARATION OF THE TEACHER FOR THE LESSON. It is not well to rely entirely on the inspiration of the moment in teaching nature lessons, any more than in any other subject, such as geography and arithmetic. Of course the teacher should possess adaptability and be able to change her plan of recitation quickly and easily if the occasion so requires. But a nature lesson requires preparation, just as the above-mentioned subjects. One chief reason for the failure of so much nature-study is the lack of thorough preparation by the teacher.

We will assume that the subject of the lesson is well chosen, that it is not some trivial matter, but is adapted to the grade for which it is intended, and that there is some definite purpose in presenting it. The subject being decided upon, the teacher must then think of what she wishes to teach about it—whether it is to be merely a description of the qualities of the object, its classification, or a discussion of its uses, etc.

She must plan this out more or less fully. Beginners had better write out such descriptions, or the steps of a classification, or whatever the matter of the lesson is to be. This matter must be logically arranged and not thrown together without any connection. More proficient teachers may be satisfied with simply thinking out the matter and jotting down an outline memorandum of it.

It is well also to put into this lesson plan or guide such points on the method of presenting the matter as will seem useful, special forms of questions, hints on the best explanations, and reference to the use of the illustrative material.

The subject-matter should be neither too trivial nor too abstruse for the class. The previous knowledge that the children may have of the thing to be studied should also be taken into account in making out the plan of the lesson. Again, the amount of matter or the number of points to be brought out should be proportioned to the length of the period for the lesson. If there is too little matter, time will be wasted in useless repetition, and if there is too much matter the whole of it cannot be completed, or all or parts of it must be slighted, and the lesson is not well fixed. Another point should be remembered in teaching nature-study: Do not think you are teaching nature-study when the lesson is simply about scientific definitions, such as veins, midrib, petiole, dentate, crenate, etc. That is simply word-study, not nature-study. Teach facts, not words.

A very necessary part of the teacher's preparation is the selection and getting together of the illustrative material for the lesson, such as the object itself, or parts of it, pictures, experiments, and stories. They should be chosen with reference to their fitness to illustrate the lesson. The matter should be

planned as if derived from a study of the illustrative material, for that is what the children must do in the recitation.

Giving the development lesson. The teacher is forearmed with a well thought out lesson plan. If the lesson is not particularly related to preceding ones, it may be introduced by a few bright remarks about the object to be studied, to awaken the interest and direct the attention of the children. Perhaps it may be well to refer to some experiences of the pupils with the object. It is always well to form a basis of previous knowledge for the new facts to be acquired. If this is done, and the new knowledge properly related or connected with the old, it is more apt to stay with the learners. If there have been previous related lessons, then quickly and briefly call to mind some of the essential facts of those lessons, such as are to be made use of in the new lesson or are needed as a basis. The basis having been established, the new lesson is then presented.

In *the development method* this is done by showing the object or other illustrations, and by means of questions directing the observation of the pupils in such a way that they see for themselves, or reason out for themselves from these observations, all the points the teacher had planned to bring out.

This questioning is an art. Hit or miss questions without any definite order will leave the knowledge gained by the pupil in a chaotic state, from which he cannot see many relations or make the generalizations he should. Therefore, follow the outline of the lesson plan and thus ask the questions and direct the observations in an orderly fashion, and then from their logical order the pupils can easily make the inferences required.

Of course the information could be imparted more quickly

and easily by the lecture method. But a nature lesson should be a mental discipline. In a lecture the listener is more or less passive mentally, and often fails to absorb fully and to retain the facts heard. But facts acquired through personal effort are apt to be remembered longer, chiefly because they are better understood. Furthermore, the practice simply in observing, comparing, and reasoning out laws and classifications is a good thing.

If the development method is properly applied it stimulates individual mental effort in the pupils and tends to accurate observation and logical reasoning. But there is a danger in using this method of instruction that it may be so mechanically applied that it sets the pupils' minds going only for a thought or so, and then they sit and wait for another mental jog in the form of a question from the teacher. Do not destroy in the children the power of initiative in thought. Counteract, if necessary, by requiring more extended description or more extended reasoning from the pupils without prompting questions, and also by varying the method of presentation; for it need by no means always be the development method.

Frequently in nature lessons it is necessary to classify objects. The comparison of different objects, and the finding of likenesses and differences by means of which the objects are grouped is excellent mental practice for the children. This comparison may be made at the close of the study of the new object, or it may be made all along during the presentation, point for point. The first method better emphasizes the comparison and tends to make the classification more effective.

Even primary children should do more or less of this.

They can easily see that the fox is like the dog, both in structure and in habits, and they will naturally group them together. But have them also note the essential differences that make one animal a dog and the other a fox. The more common type, the dog, should be studied first. Then, in studying the fox, compare his head with that of the dog; then the teeth, the feet, and the habits, as these points are brought out in the developed description of the fox. Or wait until the fox description is finished and then compare. Sometimes a superficial resemblance of two objects resolves itself after comparison into wide differences. For instance, most people call the chimney-swift a swallow. But a careful comparison shows that the birds belong to different groups. The comparison of physical phenomena, such as conduction and convection, is good practice and leads to clearer reasoning. Comparison is a necessary step where classification is desired.

Sometimes all the facts developed in a nature lesson are considered together, and some generalization is derived from them. Comparison of several objects or facts leads to classification, a kind of generalization. But sometimes a general principle is involved in a number of illustrations or experiments, and this the children are to think out. Thus, a number of experiments in heat may all lead to the conclusion that heat causes expansion.

When such generalizations have been made, the pupils should be required to think of applications of the principle in new cases. Thus, after deriving the principle of expansion by heat, let the pupils apply this principle to such cases as the setting of wagon tires, the gap between the rails, the thermometer, etc. This fixes the principle better in the

pupils' minds and shows the practical bearing of the subject.

The permanency of the knowledge acquired depends partly upon the interest in the subject, and also upon the repetition of the act of learning—that is, upon drill. This is as true of nature-study as it is of the multiplication table. And a nature lesson is not thoroughly finished when the facts have been brought out only once. It is necessary to drill on the separate facts of the lesson as they are developed, and there should be a summary at the close of the lesson. The summary is often very necessary, to fit together in a unified whole the facts that were acquired in an isolated order. This summary of what was learned in the lesson should generally be made by the pupils themselves, if they are old enough, and with only enough guidance to make it orderly. A black-board outline is useful in summarizing. This may be copied by the older pupils and used as a basis of a home task or written account of the lesson.

The pupils' answers should receive some attention. Do not accept careless, abbreviated, and ungrammatical answers. It would be pedantic to require complete statements in all answers, but, wherever proper, demand more complete expression. Pupils and teachers alike should avoid all bookishness and technicality in language. Such simple scientific words as calyx, corolla, stamen, pistil, pollen, etc., are short and have been popularized and should be used.

Rules for Questioning

In theory the development lesson strengthens the mind of the child, for he must by his own energies discover facts, make comparisons, and deduce principles. In practice,

however, a development lesson often becomes a sort of mental prop that weakens the child because he is not incited to spontaneous effort. For a teacher may by suggestive, alternative, and direct questions herself give the whole matter of the lesson to the pupils without their exerting themselves in the least. The lesson becomes simply a lecture in the interrogative form. Such teaching is wholly bad.

Questions serve as a means to reveal defects in knowledge, or to sound the extent of knowledge, or, incidentally, to secure wandering attention. But there is still another and most important use of the question, and that is to encourage and direct thought, as in the process of eliciting in a development lesson. Much of the success of the lesson depends upon the way in which these questions are worded. The following rules should be observed in nature-study, as in any development lesson:

1. QUESTIONS SHOULD BE CLEAR AND CONCISE. A vague and lengthy question cannot be understood or followed by the pupils. This question was taken from a pupil teacher's lesson plan in a nature lesson: "On a coral island in the Pacific Ocean there are a few flowers and some trees. How did they get here, since this island has only recently reached above the water after having been so long submerged?" Such a question would only bewilder the children.

2. QUESTIONS SHOULD BE DEFINITE, ADMITTING OF BUT ONE ANSWER. "Why is the lamp burning?" "What are we always doing?" are questions that may be answered correctly several times before the desired answer is obtained.

3. DO NOT, AS A RULE, ASK DIRECT QUESTIONS, ANSWERABLE BY YES OR NO. The pupil should study out for him-

self the point referred to. "Is the heron's bill short?" "Does this animal have thick fur to keep it warm?" are questions that require little if any original thought. Often, however, direct questions are permissible when employed simply to call attention to some obvious fact of which further use is then made in the development. "Can the dog climb a tree?" "*Why not?*" (Referring to the nature of the claws.) To avoid the direct question here would be pedantic and beating about the bush.

4. DO NOT ASK ALTERNATIVE QUESTIONS THAT ADMIT OF BUT TWO ANSWERS. "Is this bird's bill long or short?" "Has this plant entire or serrate leaves?" Such questions are easy to answer correctly perhaps the first time, certainly the second.

5. DO NOT ASK QUESTIONS THAT ENCOURAGE GUESSING MERELY. Children are apt to theorize about things in nature-study. Hold them to the facts.

6. AN ELLIPSIS at the end of a sentence to be filled out by the pupils is a form of question sometimes used to save time, to drill, or to make the work easy. It is legitimate to use this occasionally for the first two reasons, but the ellipsis should be carefully treated. It should still require effort from the pupil. "The motion of the earth on its axis causes day and ———" and "Molecules are held together by the force of co———" are bad ellipses and simply prompt the pupil.

7. NATURE-STUDY teachers frequently fail in attempting to bring out comparisons by using direct and suggestive questions. "Are the hoofs of the cow like those of the horse?" "Does the hen have webbed feet like the duck?" are wrong forms of questions to bring out correspondence and differ-

ences. Instead, ask the pupils directly to "compare the hoofs of the horse and the cow," and "tell how the feet of the hen differ from those of the duck." Ask them how ——— and ——— compare, and how they are alike or unlike, etc., and then the pupil must work out the comparison for himself.

CHAPTER V

ILLUSTRATIVE MATERIAL

One of the chief functions of nature-study is to cultivate the power and the habit of observation. This is possible only when there is something to observe. The object or thing studied should be actually present before the children if possible. If it is not, then the lesson is not an object lesson, and as a lesson on nature it will lose much of its effectiveness. If there is no illustrative material for the lesson there can be no real perceptions of the thing. Reference can only be made to the pupil's previous knowledge of, or experience with, the object, and that may be vague, little, or nothing. The reasoning based upon such facts will necessarily be imaginative, and conclusions cannot be immediately tested and verified. We very properly decry the old-fashioned text-book method, pure and simple, in teaching physics and geology, without experiments, specimens, and field observations. And yet many teachers attempt to give nature lessons in this unscientific and unpedagogical way. This is because they fail to realize that the illustrations are the very foundation of the lesson, and not merely an entertaining and ornamental feature.

It is customary to teach nature-study by the development method—the method of individual observation and reasoning from the object before the pupils. Thus is seen the great

usefulness and purpose of the illustrations. They are the starting point, the basis of the lesson.

The teacher should, therefore, make every effort to secure ample and suitable objects and experiments to bring out the facts of the lesson. Small insects, minerals, plants, etc., should be collected in quantity, so as to provide each pupil with a specimen, that he may be able to examine it carefully. I recall one teacher who gave a lesson on the fish. She had some small boys go out the day before and catch a lot of minnows. These she put into a number of fruit jars which she placed on the pupils' desks, so that they could easily see the structure of the fish, the breathing, the use of fins and tail, etc. The lesson was vastly more successful than if she had had only a single fish in a jar in front of the class, or had passed it around among the pupils. A single small specimen held up before a class cannot be accurately seen, and it takes extra time and repetition of directions to pass it around. This, however, must be done if only a limited number of specimens can be obtained. If the illustration is large enough it may be placed in front of the class, but in an elevated position and in good light. The other senses besides that of sight should be employed by the pupils in making their observations, where anything is to be gained thereby.

Sometimes the teacher forgets to use her illustrations, though she has prepared them and has them in class, because she gets so interested in the subject-matter of the lesson. Sometimes the illustrations are used only in a perfunctory and superficial way. The object might just as well be absent, as far as its being the basis of the lesson is concerned. The teacher should not forget that the lesson is to be developed *by means* of the illustrations.

Since so much depends upon them, it behooves the teacher to select and prepare good and sufficient illustrations. Nothing shows more the diligence and ability of a nature-study teacher than the material prepared for illustrating the matter of the lesson. It is an index of the teacher. Fitting and enough illustrations show forethought and understanding; scanty or poorly adapted material or the entire lack of it indicate shiftlessness, want of providence, or an uninventive mind.

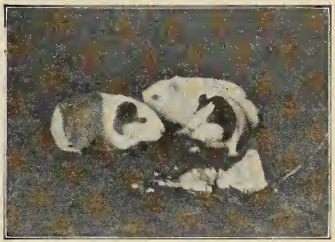


Fig. 1. Guinea Pigs.

Various kinds of illustrations should be used in nature lessons. The ideal way to teach nature-study would be to take the class out into the meadows and woods, to the brook or the lake, to the orchard or the flower garden, or to the farm fields, and there study nature unadulterated and under natural conditions. Field lessons will be referred to in a later chapter. The point emphasized at present is that the natural object under natural conditions is generally the ideal illustration for a nature lesson. Schoolroom lessons should be illustrated by the actual object whenever possible or desirable. A living, growing plant, a live squirrel or a live toad, a cage-ful of live ants, etc., all these are possible and desirable. In case the object cannot be brought into the school, let the scholars go to it. Where the live animal cannot be got, then killed and preserved specimens must do. Stuffed birds, mounted insects, specimens in alcohol or formalin, herbaria, etc., come under this head. Parts of the plants or

animals, natural or manufactured products of plants, animals, or minerals, geological specimens, astronomical and meteorological phenomena and experiments are all included in this class of illustrations—the actual thing. They are the most real.

Of less value than actual objects, but still of great value, are the following representative illustrations.

Models, Pictures, and Diagrams

MODELS of sand, clay, or other plastic material are very useful in geography. Anatomical casts are excellent in the study of physiology. The dissectible kind are especially instructive and give an idea of internal anatomy. Models of geological sections to illustrate the strata of the crust of the earth are very good. Again, a properly constructed working model of a machine or other physical apparatus adds to the interest in the lesson and helps to explain.

PICTURES may be used in lieu of other illustrations and, if well selected, may be very effective. In this day of wonderful reproductive processes by photograph, half-tone, and color photography, pictures furnish excellent illustrations in nature-study. Children naturally love them and are interested in their every detail. Pictures leave for a long time a definite image in the visional memory. The nature-study teacher may secure them from many sources. Animal pictures are to be found in natural histories, zoölogies, and animal readers; and plant pictures are found in botanies, garden books, etc. The teacher should make a nature-study picture scrap-book, by cutting out illustrations from old geographies, zoölogies, botanies, and other text-books, and from magazines and papers. Let the children also do this. Colored pictures are the best, providing the colors are true to nature, which

is not always the case. There are now procurable color charts of birds, butterflies, mammals, plants, and many books illustrated by the three-color process which are excellent. Every school ought to have them in its library. There are also large printed wall charts of plants and animals, which are useful in the lower grades. Some of these are published by the primary education journals.

Pictures often add a great deal even where the actual object or parts of it are present. Thus, a lesson on the pine tree, though well illustrated with twigs and needles, cones, cross, and longitudinal sections of the stem, bark, etc., is improved and made more interesting by introducing pictures of a pine forest, a pine tree with a man near it, for comparison of height, a logging scene, a saw-mill, etc. Pictures may show new features of the object or its natural surroundings.

Diagrams: Lecturers frequently illustrate their remarks by crayon sketches while they talk. Such lectures are sometimes called "chalk talks" and are generally very popular. The teacher should talk with her crayon if she has the least ability to draw. Frequently she can talk to better effect with her crayon than with words. Board drawings simplify explanations which, without them, would be long and labored. Sometimes the word-description calls up in the minds of pupils an erroneous image, or none at all, while the idea could have been conveyed more clearly and correctly by a black-board sketch. For example, if the teacher should attempt to describe to pupils not familiar with it the construction and operation of the common lifting pump by saying: "In the common water pump there is a barrel or cylinder within about thirty feet of the water; in this cylinder there is a piston which is moved up and down by the piston rod

which is connected with the pump handle; in the piston is a valve opening upward, and there is another valve at the top of the pipe leading from the cylinder to the water, and this also opens upward, etc."; probably long before reaching this point the listeners would have given up as hopeless the attempt to imagine the appearance of the pump. How much better it would be to make a simple rough sketch or diagram of the parts referred to, as the oral description progressed. Through the aid of the eye some sort of image would be formed, which would come a great deal nearer the reality than that derived from the oral description alone.

There are several other advantages to be gained by such sketches. Children like to see the teacher draw the object studied, and they become more interested in the study of it. Again, by shortening a lengthy description we make it more effective, so that it does not need so much repetition. Thus time is saved, another important item.

Nearly every lesson in nature-study affords opportunity for the use of black-board drawings. These may be either diagrams and sketches, or more elaborate drawings. The latter require more care and time, and should be drawn before the class period. But sketch outlines and diagrams should as a rule be drawn during the recitation, when they are needed. They lose much of their effectiveness and usefulness if drawn before. This applies especially to pictures intended to show construction (of apparatus), development (of a plant), or gradual formation (in geology or geography).

Diagrams, though more symbolical than pictures, are highly useful, especially with the older pupils. The picture shows the external appearance of a thing as the eye sees it. The diagram shows what the mind sees in it. Diagrams

are used to simplify complex structure, by representing the essentials only, or by emphasizing the important features. Diagrams show internal structure and sectional views not visible from without. By a diagram or sketch we can quickly show the construction of the steam engine, the structure of the ear, or of a flower, the cross section of a plant, the growth of a seedling, the formation of sedimentary strata, etc. If colored crayons are used the effectiveness of diagrams is greatly increased.[1]

Stories and Anecdotes: These are much used in nature-study to illustrate the qualities or the character of an object, the conditions under which it is found, etc. Let the pupils relate personal experiences with the object studied. Let the teacher tell hers. Read from nature readers and other books, to bring out further facts or to confirm those brought out in the lesson. These stories add to the interest in the lesson, especially in the lower grades. We should, however, be careful that the sources from which these stories come are reliable. Unfortunately this is not the case with many of our so-called nature readers. Sometimes a poem or a prose selection can be very properly used in the nature lesson to reinforce or to apply what was learned in the lesson, with the additional value that a new interpretation, a higher meaning, the æsthetic or the spiritual element of the facts learned may be brought out.[2]

The Experiment

To experiment is to place things under various conditions to see what will happen, and to see how the things will

[1] See Chapter VI for pupils' drawings, etc.

[2] In Chapter VI, myths and fairy tales are discussed in regard to their application in nature-study.

behave. If a thing always acts the same way under similar conditions, we say so and tell how it acts. That is, we state its *law of action.* Or, perhaps, the experiments bring out certain qualities that the objects possess, and we may then be able to classify the thing where it belongs. In general, in an experiment, we look for certain phenomena or certain qualities. These we make use of as the basis of our generalizations, which may either be in the form of a law of action, or a classification of facts or objects in their proper categories. The experiment is the scientist's great test for truth. It is the basis of practically all science.

Many phenomena in nature-study demand experiments to produce or to illustrate them. There are many simple experiments that would delight the children, give them useful information, and at the same time afford excellent practice in inductive reasoning. Touching a sensitive plant to see it fold its leaflets, softening a bone in acid to show the need of mineral matter to strengthen them, placing some leaves under a bell-glass to see the evaporation of water from the pores, testing a suspended magnet to see that it points north and south, balancing a heavy weight by means of a small one on a lever, rearing a caterpillar into a butterfly,—all these and hosts of others are fit experiments for the grades.

Consider the principle of expansion by heat. To show this it is necessary to perform some simple experiments in which this phenomenon appears. Perform the usual experiments, such as the ball and ring experiment; heat some water in a bottle with a narrow neck and note the rising of the liquid on warming; repeat with the school-room thermometer. Show also that a bottle filled with air expands when heated. In all these experiments the phenomenon of

expansion appears. Be sure that the children see it and note the cause. Then there will be no question of their concluding that heat causes expansion.

Why not let it go with one experiment? Because just one case is not sufficient warrant for a broad generalization. Several experiments, all agreeing and showing the same thing, will be more convincing than only one. To be actually positive that heat causes expansion would require us to withhold judgment until we had made an infinite number of experiments or observations on all the cases that were possible. But we are satisfied to make a fair number of tests, and then to reason by analogy and apply the law to all cases. In the above case—expansion caused by heat—if the pupil is led far enough in his studies, he will discover some anomalous cases or exceptions to the general rule. He finds, for example, that water near its freezing point actually contracts on being warmed, and expands on being cooled. So it will be well to preserve an attitude of open-mindedness in science, as in all other things, for our preconceived notions may not be quite right.

After the general principle of a series of experiments has been reasoned out, the pupils should then find applications in common life. Besides being an excellent drill in the principle studied, this will connect the school-room lesson with things of daily life.

Experiments require unusual care in their preparation and must be well chosen. The teacher ought never to try an experiment in class which she has not done before, as it may not "work," and she will then lay herself open to criticism from her pupils, who will rightly judge her as either careless in preparation or as ignorant of her subject. The omission

of some slight detail will often spoil an experiment. If the teacher does the experiment before class-time, she will see difficulties both for herself and her pupils and can prepare for them. Experiments in nature-study require no elaborate apparatus. Any ingenious teacher, aided by bright pupils, can construct and invent simple and efficient "home-made" apparatus. The boys will like to make models of machines and other mechanical apparatus. The school stove, radiator, oil-lamp, or alcohol-stove will do for a source of heat. Glasses, cups, and bottles will replace test-tubes and beakers. Spools make good pulleys. Old files or knitting-needles make excellent magnets when stroked on a magnet. Many other pieces of apparatus may be devised, that for nature-study will do as well as those which are factory-made. If there is a manual training department in the school, it should be utilized as much as possible in the making of apparatus.

The high school science teacher will generally be found ready with suggestions and assistance, if the nature-study teacher appeals to him. Apparatus and material may often be secured through him. He may be willing to give the children experimental exhibitions or talks on nature subjects. Often he has valuable lantern slides that he can show the grade children. For instance, get him to give an illustrated talk on birds, insects, plants, etc. The children would be delighted to hear these talks. He may also give experiments with the air-pump, the static electric machine, etc. Similarly, college professors may often be got to aid the grade teacher. Again, physicians and others interested in scientific lines are often willing to lend apparatus, specimens, pictures, etc., and to give elementary talks on their special

subjects. Different grades or schools may be combined for these purposes.

The Museum

Museums are places where objects of art, history, or nature are collected and preserved, not merely for their own sake, but for the pleasure and instruction of the people who come to look at them. They have so important a purpose that in large cities museums have been opened to the public on the Sabbath, that the working classes may have a chance to see them. If a museum is properly classified and labelled, its educational value may be very great.

Museums of natural history are very popular, and are much visited by old and young. Here not only the common native types may be seen, but also many rare and foreign ones.

Universities have their natural history collections, their mineral collections, their herbaria, etc. High schools have, or should have, similar small collections, if they expect to do efficient work in the sciences; and there ought to be something of the sort in connection with every common school. In Europe, notably in Germany, there are collections of natural history, minerals, plants, etc., in the common schools. Every school where nature-study is attempted should have at least a cabinet collection of specimens. These should be collected by the teacher and pupils, or donated by friends and patrons.

Making a collection is interesting work, a work in which the pupils can be easily enlisted. Ask them to bring "specimens" of all kinds suitable for preservation, and you will probably have an embarrassment of riches. The teacher on her travels, or in her vacation, should remember the

school cabinet. People who have collections of curios can often be prevailed upon to give them to the school.

FIG. 2. School Specimen Cabinet.

Place in the collection such things as these: Herbaria; plant products, such as flax, hemp, cotton, coffee, sugar;

mounted insects and insects in alcohol; other specimens in preservatives; shells; animal products like furs, wool, ivory, leather; articles in different stages of preparation, such as a shoe partly put together; fabrics in different stages; sections of different kinds of woods; illustrations of seed dispersal; minerals, etc., etc. All these things can be had for the asking or the picking up. It is a good rule to take a specimen when you find it and not to leave it till the next time you come along, for most likely it will be forgotten. If every teacher added something to the school collection, it would in a few years amount to something. If no collection has been started, the next teacher should begin one.

To be of any use a collection should be properly classified and labelled. A poorly arranged and unlabelled collection is often worse than useless. Put the insects on one shelf, the minerals on another, the shells by themselves, and the plants in another place. Put neat labels on the specimens, telling their names, where they were found, who presented them, and interesting remarks about the properties and usefulness of the specimens. In this way the collection will be of interest and value to those who see it.

Stuffed birds and other animals are always an interesting feature of a natural history collection. These are more difficult to get, but there generally is somebody in the community who does taxidermic work and who will be willing to mount a few animals for the school. Or, perhaps, the older boys, with the aid of a manual of taxidermy, could prepare a few specimens. The various game birds and mammals would do very well for this purpose, and the harmless and beneficial animals could be spared.

Incidentally it may be added here that objects of geo-

graphical, historical or archeological, and literary interest should be likewise collected and put into the school cabinet, as useful aids in other subjects than nature-study.

After a museum or collection has been established, let it not be forgotten and left to disuse. An unused, dust-covered collection of specimens represents only so much wasted time and energy.

If larger museums or collections are accessible, visit them with your classes. Take the children to botanical and zoölogical gardens and to the menagerie.

Live Specimens

Since a live creature is much more interesting than a dead one, try to secure the former for nature-study illustrations. Have the children bring to school their pet birds, squirrels, rabbits, etc. Keep them in the school for a time, and let the children make observations upon their life-habits. Have the pupils bring live insects, toads, frogs, turtles, fishes, and other aquatic animals and keep them in cages or aquaria. The metamorphosis of a caterpillar into a butterfly, the development of a tadpole into a frog, the hibernation of a toad, the emergence of a dragon-fly from its nymph case, and many other interesting and instructive things can be seen by observing these school-room animals. It is a pleasure to see aquaria with gold or other fish, and other aquatic animals and pretty fresh-water plants in a school-room. They not only vary the ordinary school-room interests, but have a decorative value. Similarly, potted plants in the windows are at the same time beautiful and furnish material for many nature lessons. A canary-bird in the room is sure to add a touch of cheerfulness.

Let it be the children's duty to provide and care for these school-room animals and plants. Teach them the needs of the creatures and see that these are satisfied. A good deal can be learned about the feeding and other habits of these creatures in the school-room. They should be looked upon not simply as decorative objects but as nature-study material.

Do not let an animal or plant thirst or starve to death if you can help it. Do not put a moisture-loving creature in a dry cage, or vice-versa. Try to make the conditions as natural for the caged animal or a plant as possible. This will require an intelligent study of the needs of each, and thus give a very good chance for nature-study.

Incidental Outdoor Observations

School-room study of nature should be supplemented with outdoor observations. Get the children in the habit of seeing the things about them. Have them report on what they see on their way to the school or on a visit to the country. After studying an object in the school-room, ask the children to observe it outdoors and to note its surroundings or its outdoor habits. Sometimes have them make preliminary observations outdoors for a future indoor lesson. Thus, in preparation for the lesson on winter birds, have the children on the lookout for winter birds for a week or so before, and let them report on their observations. These may then be summarized, and conclusions drawn from them in the indoor lesson. Similarly, preliminary observations should be made in the daily weather study.

Teach the children how to observe wild animals. If you suddenly come upon a rabbit, a squirrel, a butterfly, or a bird, stand still for a while and make no noise. Wild creat-

ures will generally not flee then, but will go on feeding or with their other occupations. But sound and sudden motions startle them. If you do not frighten the animal away at once on your approach, it may remain for some time while you are making your observations on it. You may even approach quite near if you do it quietly and slowly. Some of the most interesting and valuable observations are made in this incidental and accidental way.

It is sometimes a good plan, with the older pupils, to assign to the whole class or to individuals certain animals or plants for continued observation, and to require memoranda to be made of these observations. In this way the pupils may get some of that love for, and knowledge of, outdoor things that the naturalist possesses.

Field Lessons

The naturalist goes into the fields and woods, by the lakes and brooks, and observes and studies sympathetically the birds, the mammals, the flowers, or the rocks of the earth. It is a real pleasure for him to be out among these interesting things. He sees nature under the most natural conditions. He sees the natural setting of things, how they are adapted to the conditions under which they live, and how animals and plants affect each other or live together. He has a broader view of nature, a truer view than he who studies these things indoors, under the artificial conditions of the laboratory or the school-room. This is true nature-study. The indoor study of things that naturally belong outdoors, among other outdoor things, can never show their true aspect. Moulded heaps of sand are a pitiable apology for real hills and mountains, "the glory of our earth and

the culminating points of scenic beauty and grandeur." A plant in the school-room does not show the natural mode of growth, and an animal in captivity or dead is not the creature of the forest.

Field lessons will do much to correct this abnormal, partial, and indoor view of nature. This is the ideal way to study natural history and earth features. This is the only way to imbue the child to a certain extent with that happy spirit and love for nature so peculiar to the naturalist.

Boys and girls brought up in the country have a greater stock of nature lore and field and woodcraft than the average city child. To very many children in our large cities the country, with its woods and birds and flowers, is a foreign land. To them an excursion into the country would be a rare treat, and an occasion that would open the eyes to many wonderful and beautiful things. But field lessons would be profitable also to children in our smaller towns. Even the country child has much to learn about the wild life around him.

To make field lessons a success the teacher must have a definite object in the trip. Aimless wandering about with a class accomplishes nothing. Let the pupils understand that the trip is not for a romp and a frolic, but a lesson. Tell them what they are going out to study. A good teacher will be able to conduct a class of twenty-five or thirty pupils on a field trip, but this number is too great for the best results. Large classes had better be divided. Sometimes older pupils may act as assistants. There is no need of formality and military order on these occasions, but let this be understood by all: that the class must not scatter widely, and that every child must come immediately at the teacher's call, when she

has something she wishes all to see. The field study of the object may in general follow the development method; that is, the pupils are to make the observations themselves and to use these in their reasoning. If the lesson is difficult and much has to be developed in the field, it should be reviewed and summarized in the school-room afterwards. Older

Fig. 3. Nature-Study Class on a Field Lesson.

pupils may be directed to make notes on the trip, and also sketches, to use later in writing an account of the studies made.

A field lesson requires preparation just as any other. The teacher should previously look over the ground and find a suitable locality for the lesson, else much valuable time might be lost with the class in hunting about for the object of study. Moreover, the teacher will have a chance to examine the object and thus prepare for emergencies that may come up in the lesson.

If school officers and patrons object to these field lessons in school hours, they may be given out of school hours and at recess. The teacher who gives successful and instructive field lessons under such conditions will soon be able to convert those who object to them.

Pupils should be taken out for collecting plants, animals, minerals, and the like. These trips may be made much more than mere collecting trips, for the environment and the habits of the animals caught may be studied at the same time. The school cabinet can be supplied on such trips.

Some teachers have the idea that one has to go far to give a field lesson. This is a mistake. The school doorstep, the school ground, the street or road in front of the school, a vacant lot or a neighboring field, a city park, a flower garden, a roadcut, a hill nearby furnish suggestions for field lessons not far from the school.

The following are some suggestions for field lessons:

Zoölogy: Ant-hill. Bee-hive. Collecting insects. Observing insects pollinating flowers, destroying crops, foliage, etc. Birds, nests, and habits. Lake or stream for aquatic animals, such as mollusks, crayfish, insects, fish, frogs, etc. Seashore for marine life. Visit to a menagerie or a zoölogical garden. Museum. Visit to a farmyard.

Botany: Buds. Tree study. Visit to a park; to a forest. Collecting autumn leaves. Collecting fruits and seeds and noting means for dispersal. Nutting expedition. Collecting and studying spring flowers. Same with flowerless plants. Visit to a flower garden and noting relation of plants and insects. Work in the school garden. Visit to a farm.

Earth Study: Drainage of the school-yard on a rainy day.

A brook. The river. Ravine. Waterfall. Cave. Swamp. Hill. Mountain. Bluff. Roadcut (stratification). Quarry (strata, fossils). Mine. Spring. Artesian well. Weathering and soil formation. Glacial drift. Glacial markings. Collecting soils, sand, pebbles, rocks, minerals, fossils. School excursion to some rugged and romantic spot.

CHAPTER VI

CORRELATION

'Twould be endless to tell you the things that he knew.
All separate facts, undeniably true,
But with him or each other they'd nothing to do,
No power of combining, arranging, discerning,
Digested the masses he learned into learning.
—*Fable for Critics*, LOWELL.

A FACT in history may be studied in an isolated way. But when the student sees how it is related to others, how it had important historical bearings and consequences, then it is better understood than when simply studied by itself. The study of a fact in association with other facts leads to a better knowledge of the fact itself and to the discovery of a wider truth. The more associations we can connect with a fact to be acquired, the better it will be fixed in the memory. This may be done by looking at it from different points of view, or approaching it along different lines of thought. For example, coal may be studied in the nature lesson as to formation and composition. If the State of Pennsylvania were studied at the same time, it would greatly enhance the nature lesson if the coal mines and the coal industry of that state were also studied. On the other hand, the geography lesson would not lose anything in interest or effectiveness because of the nature lesson on coal.

Thus one subject can be made to help another by forming new associations about the things studied. Again, the subject of respiration can be made clearer and more interesting by some experiments on the properties of oxygen, CO_2, nitrogen and water vapor in the air. The usefulness of the lesson in chemistry will become apparent to the pupils in the following lesson in physiology.

These illustrations show in a general way what is meant by correlation in education. To correlate subjects is to bring out useful connections between them, to explain one lesson by another, to add interest to the facts in one lesson by showing their relation to facts learned in another. In this way associations are formed that help the pupil's memory.

Nature-study lends itself very easily to correlation with other subjects, especially with the formal or expression studies, such as reading, language, writing, drawing. It is very profitable to pursue nature-study and geography together. It is a good plan to study in the nature lessons the animals, plants, minerals, and natural phenomena referred to in geography.

There must be something upon which to practise language, writing, drawing, etc. The nature lessons may afford suitable matter for many lessons in these subjects. The thing studied in the nature lesson may be the subject of the reading lesson, and may often be used as the object in a drawing lesson. In this way there is a saving of time and energy on the part of pupils and teachers.

Nature-Study and Geography

Geography includes more or less all of the natural sciences, and if correlation is ever desirable it certainly is in the case

of this subject and nature-study. In fact, much of the geography would be unintelligible or vague without a study of the underlying phenomena and the animals, plants, and other natural objects referred to. Many teachers do make a study of these things in geography, but that amounts only to the introduction of nature-study into geography. More would be gained by studying these natural objects and phenomena in a separate nature-study period, when they could be discussed more in detail. They should be still used as explanatory of the geography lesson.

Sometimes it is difficult to decide whether a certain lesson should be called geography or nature-study. The fact is that much of geography is pure nature-study and might very properly be called so. This is especially so with the physical part of the subject. Of course, political and commercial geography bring in more of the human element, and yet even here there is almost constant need of the aid of nature lessons. A few illustrations of correlation between geography and nature-study will be in place.

The child's introduction to formal geography should be through nature lessons on the surroundings of his own home. In field lessons he should learn to recognize the simpler earth features and note their causes as far as he is able, and also to note the present operation of the earth-shaping forces. This might be called Earth-Study. Then he should study a little about the effects of heat and cold, atmospheric moisture, clouds, rain, snow, dew, ice, and wind. He should learn the points of the compass, the use of the weather-vane and the thermometer. This might be called Weather-Study. A few simple astronomical facts appropriate to such young minds should be studied, such as the most obvious facts about the

sun, moon, and stars, under the name of Sky-Study. The occupations of man, especially those depending more directly upon natural resources, and the plants, animals, and common minerals that man makes use of, should be studied. All

Fig. 4. Brook at Work Removing a Landslide.

this is geographical material. In this way the study of geography is opened up gradually and interestingly.

When formal geography is taken up, there is still use for an accompanying course of nature-study. The complicated subject of the winds, including the trades, can never be well understood without some lessons in the physics of the matter. The study of the local weather in nature-study helps the children to understand better the climatic conditions in other regions. The composition of the air should be studied

in connection with the subject of the atmosphere in geography, as should also atmospheric pressure and the barometer. Coal, marble, iron, and other ores, natural gas, oil, and other mineral products,—the nature, adaptation, and uses of plants and animals in different countries, also their distribution, are things that can be studied better in nature-study than in geography. Geological features, such as the coral islands, mountains, stream action, rock strata, glaciers, glacial drift, etc., should be considered in nature-study as well as in geography. In geography the physical basis for the distribution of peoples, limiting of countries, location of cities, spread of immigration, and establishment of certain industries in certain regions should be well noted.

A course in geography with a correlated course in nature-study is a great deal richer, more interesting, and valuable on account of this correlation.

Nature-Study and Art Study

Flowers, butterflies, and birds are so beautiful and rich in color that they appeal to the artistic sensibility of every child. Nothing better can be found as subjects for lessons in painting and drawing than the forms and colors of nature. Because of their objectiveness, striking colors, and beauty of form, the objects used in the nature lesson may again be used in the drawing or painting lesson. This does not necessarily mean the prolongation of the nature lesson under the guise of an art lesson, for the object need not be considered from the scientific point of view at all, but purely from the artistic side—beauty of color, form, grace, proportion, artistic grouping, etc. In this way the material for both lessons may be secured at the same time, and a saving of energy be effected

for the busy teacher. And the fact that the object has been observed more or less closely in the nature lesson as to its structural details, colors, etc., can only be of service to the art lesson. The changing seasons, with their variety of life and inanimate scenes, add an additional interest and charm to the art study.

The nature-study material is especially useful in the art work in the primary grades, since the children are still accustomed chiefly to objective thinking, and their imaginative and creative powers are not highly developed. Therefore the art work must be mainly based upon the observation and representation of what the children can see, that is, actual things.

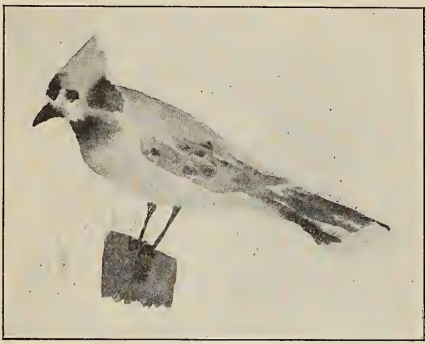


FIG. 5. Blue Jay.
(From a painting by a pupil of the fourth grade.)

The children's æsthetic appreciation of nature can be greatly developed through the artistic study of natural objects and scenes. To paint a bit of landscape in different seasons or in different lights, to observe the less obvious, though no less pleasing, subtleties of harmony of colors, subdued hues, and picturesque details can only increase the power of seeing the beautiful in the landscape. Similarly, the representation of birds, insects, flowers, etc., makes them more significant and interesting.

There is also a reflex benefit from the art lesson upon the nature lesson, if the two have been correlated as suggested. A child that has drawn carelessly the margin and shape of a leaf, and has his attention called to his inaccuracy, will have his scientific understanding of the leaf made clearer and more definite. The visual image left by the drawing lesson will assist the nature-study. A child who has carefully and accurately drawn a hard and a soft maple leaf must have the similarity and also the difference of these two leaves impressed upon him all the more deeply. The correct painting or drawing of a natural object clarifies and makes more definite the mental image the child may have got from the object in the nature lesson.

When the children have become more proficient in drawing, etc., they should be required more and more frequently to represent the objects of the nature lessons with the scientific aspect in mind. Require them to illustrate their nature work with correct and carefully drawn illustrations showing form, color, proportions, details of structure, relationship of parts, diagrams, development of growing things, principles of experiments, interrelations of plants and animals, structure and action of simple machines, plans of construction, plans of the garden, etc. These drawings are avowedly from the nature-study point of view, but the principles of art may be applied to them nevertheless. Many of these illustrations may be made first purely from the art side and afterwards applied to the nature work, such as written work, records, essays, charts, booklets, herbaria, portfolios, etc.

I would urge the use of diagrams in the upper grades. This requires a certain amount of maturity, an ability to represent what the mind sees, often in disregard of actual

form, color, and details. But they are very useful in showing relationship, sequence, simplified plan of structure, etc. Maps and construction plans are thus diagrammatic and symbolic, and the same practice should be extended to the representation of physical apparatus, physiological structure, geological formations, flower plans, insect structure, etc., in elementary science. Such drawings often show relations better than do the more artistic and complete pictures. Black-board drawing should be required more than is usually the case. Let the children tell on the board what they see. This is especially good for rapid and diagrammatic sketches.

I do not propose to say much in regard to the methods and media to be employed in the art work, for that would be infringing too much upon the artist's domain, and they differ greatly in different schools. But it may be said in a general way that color seems to be the best and easiest mode of expression in the lowest grades, and should be the first and chief medium used. Wash drawings in ink are also very successful, especially silhouettes in the lowest classes. Crayon and pencil work are more difficult, but when once acquired with some proficiency they are excellent for pictorial representation of detailed structure study, action, illustrated stories, rapid sketches, etc. In higher grades, drawing is perhaps the best method for developing accuracy in line and proportion. Charcoal is also a very successful medium, especially in study of scenery, trees, fruit, etc. Cut-outs of paper, made freehand and mounted, are easy and interesting for the little ones, and are suitable for compositions of animal scenes, child life, etc. Modelling may be applied to the representation of simple animals, flowers, fruit, vegetables, etc., and finds a limited application in nature-study. Modelling of

earth features in sand, etc., may perhaps be referred to here. Design draws heavily upon the nature-study for motives and patterns. The most usual decorative forms of design are derived from nature. Numerous applications of this study may be made in nature-study itself, as in the decoration of written work, essay and booklet covers, charts, portfolios, note-books, record-books, etc.; and, of course, the field is unlimited in manual work, textiles, basketry, pottery, and in art study.

Suggestions for color studies and combinations may be found in the colors of flowers, autumn foliage, insects, bird plumage, and the tints of the water and sky. We generally begin color study with one of the most beautiful phenomena of nature, the spectrum.

We can learn a great deal in this country about the artistic arrangement of cut flowers. A spray of blossoms may lose half its beauty from a poor arrangement in the vase. The Japanese are able to teach us much in this respect.

One function of the art work in connection with nature-study should be the observation of the beauty in common things. Old gnarled trees, a neglected corner, the common weeds, etc., have a beauty to those who can see it.

Somewhat allied to art study is the artistic planning of flower-beds, borders, the school or home garden, and tree arrangement on the lawn. In the higher grades the elements of landscape gardening may be successfully taught. We should, however, begin in the lower grades to cultivate an appreciation for beautiful school grounds, home grounds, boulevards, and parks, and develop the civic improvement idea.

The following is a suggestion of a few art topics chosen from the nature course. It may be adapted to the artistic

principles and the special media taught in the different grades. Numerous suggestions for art lessons are suggested in the course of study, chapter XX.

Subjects for Painting in Color: The landscape (forest, meadow, fields, water) at different seasons and in different lights. Keep a monthly record of a bit of scenery, showing seasonal changes. Grass and sky, clouds, trees, and bits of water. Summer greens, autumn foliage, late autumn browns, snow scenes. Bare trees and forests, and evergreens in the snow. Fruit trees in blossom. The return of the leaves. Gorgeous sunsets and sunrise. Cloudy days and twilight effects. Sun and moonlight reflections in the water. Characteristic forms of trees in foliage. Trees with fruit. Nutting scenes. The wind and the falling leaves. Farm scenes, grain fields, the harvest, cornfields and pumpkins, the farmyard. Fruit studies, nuts, vegetables, ears of corn, heads of grain. Store scenes with products of the farm or orchard. Ferns and mosses, toadstools, shelf fungi, decaying trees and logs. Grasses, sedges, cattails. The winds of March with kites, windmills, and sailboats. Bonfire. Candle. Storms. Rainbow. A brook with trees. Lakeshore. Dunes. Meadows. Marsh. Hills and ravines. Sliding and skating. Child sports with nature backgrounds. Illustrations of nature stories and nature myths. Brightly colored birds, nests, and eggs. Butterflies, moths, and other insects. Goldfish in aquarium. The flowers of the seasons. Flowers and butterflies, bees, etc. Common weeds. Potted plants and window-box plants. Bulbs, tulips, etc. Gardening scenes—spading, raking, sowing, weeding, watering. Squirrel, fox, wolf, cat, dog, horse, cow, sheep, and other animals, or illustrated stories about them.

Subjects for Washes in Ink: Many of the above subjects may be represented in values in this medium. Silhouettes of domestic animals, birds, fruit, vegetables, seed-pods, seeds, grasses, child sports, illustrated animal stories, leaf forms, trees. Weather scenes, those above, wind, snow, snow and ice sports. Twilight and cloudy day scenes are especially well represented in ink.

Charcoal is an excellent medium for shading of fruit, vegetables, etc., for landscapes, foliage, sky and weather scenes.

Drawings — Crayon, Pencil, and Ink: Many of the topics under color. Fruits, nuts, vegetables, grass, grain, sedges, seed-pods, seeds, seed dispersal, leaf forms, trees bare to show branching, trees in foliage, flower parts, seed study, seedlings, stages of growth, opening of buds, insect development, growth of tadpoles, landscape sketching, plans for construction, apparatus and experiments, plant and animal structure in detail, rapid sketching and diagrams.

Fig. 6. Pupil's Drawing. Tulip.

MODELLING: Fruit, vegetables, simple animal forms, flower-pots, etc. Geographical modelling.

DESIGN: Leaves, flowers, seed-pods, seeds, fruits, birds, simple mammal forms, butterflies, moths, dragon-flies, fish, etc., applied with or without conventionalizing to show repetition, alternation, rhythm, and balance in borders, panels, and surfaces. Apply to useful articles.

CONSTRUCTION: Models of houses, stores, gardens, farm scenes, transportation, primitive life and industry, Indian life, etc. Making bird-houses, windmills, scientific toys, mechanical models, etc.

Nature-Study and Literature

There is a great abundance of "Nature Readers." Many of them are of questionable value, being non-adapted, unscientific, sensational, or trivial. Some are written in a simple narrative style and are designed to impart information. Such are often of much use to the pupil and the teacher. This kind should be found in every school library. Give the pupils books on natural history, hunting, invention, discovery, and travel. Let them read these in the nature lesson, and at home, or in vacant periods.

Nature books for the lowest grades are written usually in a style supposed to be more pleasing to the little ones. The facts are stated in child language, from the child's point of view, and with surroundings that appeal to the child's tastes and sympathies.

One style especially is commonly employed in primary readers, namely, that of personification. All kinds of natural objects are given the power of speech and are made to relate

the story of their lives or to describe themselves. It is no doubt true that children like this style. It puts them on a friendly and sympathetic footing with these natural objects. And so long as the essential qualities of the thing are preserved there can be no objection to the occasional use of such literature.

But when it comes to the use of myths and fairy tales as nature-study material that is used for teaching about natural things, a strong protest should be raised. Their subject-matter is admittedly not based upon fact. The mere fact that the characters in them are often animals, plants, and other natural objects is no reason why they should be used in nature-study. They were not intended to teach about nature. Their purpose is merely to entertain, or to teach some moral truth, and in literature, not nature-study, they find their proper place. To a certain extent the same objection holds for other allegorical or figurative representations of nature. We find much of this in our best writers, Shakespeare, Milton, Wordsworth, Bryant, and others. We enjoy the nature literature of these writers, not because they teach us anything about the natural objects referred to, but rather because they reveal to us some moral, æsthetic, or spiritual aspect of nature, and because they help to place us in the proper attitude to appreciate it. That is, these writers bring out the human element or interest in nature rather than teach botany, zoölogy, or any other science. The proper place for this kind of literature is not in science.

There is no particular objection to the introducing or closing a lesson with some literary gem, a bit of personification, or a fairy tale, in order to place the children in a sympathetic and attentive attitude toward their work, or to give

them the poets' interpretation of the relation between man and nature. But to attempt to use such literature as information material is wrong, and a perversion of the proper use of literature. The best way to study nature is not to read some fine lines about it, but to take the actual things themselves and observe and study them. The excessive use of all this figurative literature and fairy lore in nature-study is to develop gushing, rhapsodizing, and sentimentalizing, which may reveal some enthusiasm but little nature knowledge. It is a wrong notion that a six-year-old child cannot understand, and does not like, good, simple, straightforward language; that he cannot grasp a fact unless half-hidden under metaphors; that he has a natural distaste for the plain, unvarnished truth; and that the only way to give him a knowledge of nature is to smuggle it in under the guise of a myth or a fairy tale. Conscious effort in study is a good thing. It develops mental strength and self-reliance in learning.

Science, whether studied in the high school or in the primary grades, demands that the minds of the pupils shall follow the laws of logical reasoning, that the imagination be controlled, and that the physical qualities of the things studied, and not the creations of the imagination, shall be the basis of the reasoning. As soon as imagination, unchecked by the facts in the case, comes in, nature is no longer seen in its true aspects.

In general, it seems best that nature stories and nature literature should be read after the nature lesson has been developed in the legitimate way. Then the child has a correct idea of the object. If he now reads a figurative poem, a fable, or a fairy tale in which the object of the lesson appears

as a character, the child can see the application of the personification, he gets the point of the story, and there is not so much danger that he will accept as true any assertion which is purely fanciful.

PART II

SPECIAL METHODS IN BIOLOGY

CHAPTER VII

ANIMAL STUDY

Primitive, savage man subsisted chiefly upon game and fish. The old hunting instinct is not dead yet, but is latent in nearly every boy and man to-day. The pastoral stage, when man succeeded in domesticating and herding sheep and cattle, was of great importance in raising him in civilization. His existence no longer depended solely upon chance and skill in the chase. He became more provident, and also more settled nomadic, instead of ranging far and wide for game. A still greater progress was made when he succeeded in domesticating the horse, and used it and the ox as beasts of burden. Now he was able to use greater forces than his own, and he made great strides in commerce and in agriculture. The races that never domesticated beasts of burden remained in a backward state. The American Indians had not learned to use any strong, serviceable animal for carrying or dragging loads. Along with food and work animals, primitive man domesticated a few other animals, such as the cat and the dog, more for pleasure than for service.

Thus we see that man has in the past had a very great and practical interest in the animals. The horse, the cow, sheep, poultry, and pets are just as necessary to us as they were to our ancestors. Therefore animal study is very proper for the schools.

A large element in the life of a child is the companionship of a dog, a cat, or some other pet. The care of pets and the playing with them make a very practical form of nature-study. The same is true of the treatment of farm animals.

The wild animals are even more interesting than the more familiar, though more important, domesticated animals. Their very rareness and shyness make them interesting. The most matter-of-fact, the most unimaginative persons will stop to look at a deer, at a squirrel, an eagle, a humming-bird, a strange beetle, or a beautiful butterfly. Children greatly enjoy the study of wild animal life.

Fig. 7. Good Comrades.

What are they interested in? They want to know what the creatures do, how they live, what they feed upon, what good or harm they do. Let this be a guide in animal study. The structure does not generally interest children as much as the activities of the animals. Especially is this the case when structure is studied simply in itself, without relation to its functions or to the mode of life of the creature.

And yet, if properly presented, this study of structure is as essential and useful as the study of the habits. When we

teach the children why a cat can climb a tree or lick a bone clean; why water rolls off the duck's back; why the duck is such a good swimmer; how the toad seizes its prey; why the rabbit cannot be easily seen; how a squirrel opens a nut; why you can pull an angleworm forward but not backward from its hole; how a fish breathes; how and why a cow chews the cud; when we teach about these habits of the animals we must also teach structure. The structure helps to explain the habits and vice versa, and must, of course, be studied for purposes of identification and classification.

Mere structure study, details of anatomy, unconnected with functions and mode of life are very uninteresting. But when the beautiful adaptations or fitness of organs for their use, the general adaptation of form, covering, color, etc., the surrounding habitat, or the mode of life of the animal are made clear, then structure study is intensely interesting as well as instructive.

What kinds of animals shall be studied? Animals of many classes. The mammals and birds, also lower forms, such as insects, mollusks, coral, sponges—all appeal to the child and he can learn something about them all. The little ones like to study about their pets, the domesticated animals, and the commoner wild forms. The older children prefer the less familiar. Old and young like to study about the animals of distant lands. The lion, the elephant, the eagle, the strange creatures of the sea appeal to their admiration or imagination. By all means include bears, wolves, lions, tigers, whales, seals, etc., in nature-study. Let children study the Big Game.

Outline of the Study of an Animal

What should be taught about an animal depends partly upon the age of the pupil, the general purpose of the lesson,

and the animal itself. But for a general descriptive lesson the following are points to consider.

Primary pupils should pay more attention to the habits and doings of the animals than to their structure, though this should not be entirely neglected. Older children should go more into details of structure, should reason out the adaptations, and attempt more comparison and classification. Primary pupils can see many adaptations to function and mode of life, and they can also make simple grouping or classification.

Fig. 8. Bat with Membrane Wings.

In the lower grades it is a good plan to take up first the habits of an animal, then its structure. This is more interesting; but occasionally the structure should first be studied, particularly when an animal is studied as a type of its class.

In the higher grades it is better to begin more frequently with the structure, and from this infer points in habit or mode of life, even as to habitat and food. At any rate the habits will be better understood if the structure has been first studied. Note only such details of structure as are necessary for identifying the animal, or for its classification, if that is desired. This then amounts simply to a study of the gross anatomy. Study the general appearance as a whole, including covering and coloration. Follow some orderly method of studying the chief parts of the body and its appendages. Do not with-

out good reason skip about from head to feet and back to head. Not all the parts will require notice, only such as are characteristic of the animal. Bring out well the protective character of the covering, as to color, texture, warmth, etc., and the fitness of the different organs for their uses. This may be done when the habitat and the mode of life are considered.

As for internal structure, we need very little of that in nature-study. It is necessary to refer to the gills of fish, to the complex stomach of ruminants, to the air tubes in insects, and a few other facts of internal anatomy. But generally stick to externals.

Under habits and mode of life consider where the creature lives, under what conditions, and note how it is adapted in structure. Note the food and the feeding habits, and the relation between food and mouth structure and organs of locomotion. If the creature is alive observe as many of the life habits as possible, movements, feeding, sleeping, treatment of young, etc.

Animal stories and anecdotes and experiences of the children should be related in this connection.

The economic aspect of the subject should be studied. Is the animal of any use to man? Is it harmful to man or other creatures? How? What remedy have we against it, if harmful? What useful products do we derive from it, if any? A brief study might be made of the modes of capture of the animal, or of the preparation of the useful products derived.

Animal study ought to be comparative, partly for the sake of association, and for classification where that is desired. This classification should be untechnical and based upon a

simple yet accurate comparison. Where a regular course in nature-study is provided for, it is better to plan the animal lessons in such a way that the animals may be studied comparatively and classified. Thus a series of lessons might be given on a group of mammals, or on this division as a whole, or on the insects, or the birds, etc. Beautiful and instructive relations could then be seen, which could never have been brought out in a promiscuous study of plants one day, birds the next, insects the next, etc., without a chance for classification.

In the primary grades nature-study is chiefly observation of the habits and general appearances of creatures, but even here a little comparison and broad classification would be profitable.

The classification need not be emphasized, and certainly it should be very untechnical. Sometimes it is merely sufficient to group the animals together and the relationships may be incidentally referred to, or even left wholly unmentioned, for the pupils to see for themselves from the grouping. Or tell the children that they are going to study the old Tabby-Cat and its Wild Relations, or Wild Dogs, or the Cow and her Wild Cousins. With higher grades the classification should be much more prominent and systematic.

Courses in Mammal Study

It is not very material with which group of mammals we begin in nature-study. In general begin with the more familiar as types and then study the stranger forms. More will be gained if a series of lessons can be given upon the mammals, so that they may be studied comparatively and classified. Hence it is well to select the mammals be-

forehand with this purpose in view. Select the best types and the most important mammals under those types. These should be such as are found in the child's environment, or such as are frequently mentioned in literature and in geography. In teaching about mammals with classification in mind, be sure to bring out the distinctive characteristics by which the animal is classified. Be sure the children grasp the idea of the type or the meaning of the classification. That is, the children should know what a ruminant is when ruminants are studied, and just why the dog, the fox, and the wolf belong to the same group.

In the first lesson in the course the definition of mammal may be derived from a study of the first type. Call attention to the chief differences between mammals and birds and other classes. The other mammals studied afterwards should be considered in the light of this definition. Another way of arriving at a definition or the idea of mammal is to wait till various groups of mammals have been studied, and then to note the common characteristics of the different animals, and also the different respects in which the mammals differ from birds, reptiles, etc. In this way the children reason out the definition for themselves.

The following list of mammals is probably too comprehensive for most schools, but it is suggestive of what is meant by a course in comparative mammal study. Several mammals are mentioned under each type, but all of them need not be studied if time will not permit. But the greater the number of animals of a class the better the opportunity for detailed comparison. This course is intended to give a general idea of the mammal kingdom as a whole.

MAMMALS.

I. Carnivorous Mammals (Flesh-eaters).
   1. Canine (Dog) Group: Dog (type), fox, wolf, coyote.
   2. Feline (Cat) Group: Cat (type), wild cat, panther, tiger, lion.
   3. Bear Group: Bear, raccoon, mink, weasel.

II. Herbivorous Mammals (Grass-eaters).
   1. Ruminants (Cud-chewers): Cow (type), bison; sheep, goat; deer, reindeer; camel.
   2. Other Herbivorous Mammals: Horse; elephant; pig.

III. Rodents (Gnawers): Squirrel (type), mouse, rabbit, beaver.

IV. Insect-eating Mammals: Bat, mole.

V. Whale.

VI. The Monkey Tribe.

VII. Man, in relation to the above.

In order to get a more detailed classification we must restrict ourselves to a smaller number of groups. The rodents by themselves, or the ruminants alone, would offer an excellent material for making finer distinctions.

The most common wild animals which do not flee into the wilderness at the approach of the settler, but continue to live with us on our farms and even in our towns are squirrels, chipmunks, gophers, woodchucks, muskrats, rabbits, rats, and mice. These little animals are fairly numerous and often quite tame, and can be easily observed in their free state. They are all rodents and form a most excellent group of animals for comparative study. The beaver, the prairie dog, and the guinea pig may be added to the list. The beaver is especially interesting to children on account of its ingenious ways and its association with the early settlement of this country, when beaver fur was an important article of barter with the Indians on the frontier.

Another good way to study the mammals is to consider those which furnish us with food and clothing. Study the general structure of these animals, their life habits, and the way in which they are useful to man. The industries connected with them, such as the herding, shipping, meat packing, leather making, textiles, etc., should also be referred to.

Study the cattle industry. Refer to the ranch life, the shipment of the cattle, and the packing of the meat in the large cities. Refer to the dairy industry and its processes. Bring out the dependence of man on animal food. These lessons go well with geography, physiology, and domestic economy.

Children in all grades are much interested in fur and fur-bearers. Give a series of lessons on the bear, fox, beaver, mink, muskrat, seal, etc. Do not neglect the hunting and trapping. Bring out the adaptation of the animals to the climate, the aquatic life, the protective coloration. Note the structure of the fur, and how it differs from hair and wool. The preparation of the fur for the market is an interesting process. Visit a fur factory. Note what articles are made of fur. These lessons are most appropriately studied in the winter. Examine the garments worn by the children and try to distinguish the different kinds of fur. It should be remembered, however, that the commercial names are no guarantee that the fur came from the animal to which it is ascribed. Sometimes an unusual name is given to the fur of a very common and perhaps despised animal. Thus Genuine Brown Marten or Alaska Sable is simply a euphonious name for skunk. Blended River Mink means muskrat, and Siberian Bear is simply the long-haired wool of an Asiatic Goat.

Leather should be treated in a similar way. In the higher

grades perform simple experiments in tanning. Visit a tannery if one is near. Visit a shoemaker's or a harness shop, and look at different kinds of leather and see how they work it. Visit a shoe factory if possible and see how a shoe is made. Make a list of articles made of leather. This subject correlates well with the geography of a manufacturing town.

Study the wool of sheep and goats in a like manner. Refer to the herding of sheep and Angora goats in this country; the shearing, spinning, weaving. Visit a spinning and weaving mill if possible. Study the old-fashioned spinning wheel. Examine the children's clothing, and show the wool in the cloth. Bring out the great importance of wool to mankind.

CHAPTER VIII

BIRD STUDY

Birds are the most fascinating and entertaining of our wild animals. Everybody likes the little feathered songsters. Their nimble, careless ways, their evident enjoyment of their freedom, their wonderful power of flight, their cheerful twittering or their bursts of melody all tend, for the moment at least, to make our spirits lighter and happier. The birds make the fields and woods full of pleasure for us.

Shy as most birds are, many kinds seem to prefer the neighborhood of man. Man plants and cultivates vegetables, grains, and fruit. Since every cultivated plant has its insect enemies, the greater the cultivation of farms and orchards, the greater the food supply of the birds. Hence we find more birds about farms and villages than in the dense forest or in uncultivated and unsettled regions. This applies chiefly to the song birds, and is, of course, not true of many game birds. The birds are a very great help to the farmer and fruit grower, and if they do take a few berries or a little grain, we should not begrudge it to them. So we have a practical reason why we are, or should be, interested in the birds.

There are many other associations that make us love the birds. It almost seems to the farmer's boy that the first bluebird is the cause of spring. And though one swallow may

Fig. 9. A Female Rosebreasted Grosbeak with Young.

not make a summer, still it is a sign of the times. The fall migration of the birds is a warning that winter is nigh. A touch of brightness is added to the winter landscape by the bluejays, snowbirds, and chicadees that remain.

Naturally, the open country and the semi-rural outskirts of our cities and villages are the places where birds are found in greatest abundance. Yet in the heart of New York City, in Central Park, Mr. Chapman found 130 species of wild birds. Many stragglers may be seen in our shade trees, on our streets, on the lawns, and in the backyards of our cities. Even in a crowded city street the house sparrow, the dove, and the martin may be seen.

People would derive more pleasure from the birds if they knew their names and something about their habits. Says Neltje Blanchan, the lover and writer of birds: "Not to have as much as a bowing acquaintance with the birds that nest in our gardens, or under the very eaves of our houses; that haunt our wood-piles; keep our fruit trees free from slugs; waken us with their song, and enliven our walks along the roadside and through the woods, seems to be, at least, a breach of etiquette toward some of our most kindly disposed neighbors."[1]

One result of our modern scientific studies in the high schools and colleges was till very recently to take the students away from the real, living nature, and to give abstract ideas of physiology, morphology, etc., instead. A laboratory course in botany with the microscope may, after all, not make the student familiar with the flowers and trees in the fields and woods. Many a student who has had such a course cannot name and give the chief characteristics of the wayside

[1] "Bird Neighbors."

flowers and the shade trees along the streets. Outdoor study has been sacrificed for laboratory work. We try to make microscope scientists instead of naturalists in our higher schools. Now, I believe that it would be better for the average person to be something of a naturalist than a laboratory

FIG. 10. Catbird and Nest.

scientist, for the former has a happy, sympathetic interest in outdoor life and things, while the other has only the narrower indoor view. I do not by any means wish to belittle the importance of the great amount of scientific work done in the laboratories by competent investigators. But what I have said applies to the average person's scientific requirements for the ordinary purposes of everyday life.

The common birds are thus neglected in most secondary schools, and those who are called upon to teach find themselves deficient in the knowledge of birds, which are a very important subject in every course in nature-study. Teachers should strive to make up this lack. There are many excellent colored bird keys, with which the most common birds can be identified, and a knowledge of them will not only be of great use to teachers in nature-study, but will afford much pleasure.

Observing the Birds

The ideal way to study birds is to go out and observe them in their native haunts. Most birds are shy and rather rare, so it is not practicable generally to take a class out to study any particular kinds. They would fly away, or hide, at the approach of the class. On field trips with a class, birds may be met with incidentally, but cannot be depended upon for a lesson. Of course, such birds as English sparrows, doves, eaves-swallows, bank-swallows, which are tame or live in colonies, can be well studied with a class. Or, if a nest has been discovered in a good location, the class may make observations on the eggs, the young, and some of the habits of the parent birds in taking care of the young.

But the best bird study is carried on by individual observation, or by a very small group of pupils. Get the children to be on the watch for birds. Have the older ones make notes of their observations. Perhaps assign special birds to individual pupils or to a group. For instance, have some observe and report on the English sparrow, others on the robin, bluebird, swallows, etc. Assign especially to such pupils at whose homes certain birds have nested the observa-

tion of the habits of those birds. These observations may then be utilized in indoor lessons.

For the purposes of nature-study it is not necessary, it is even contrary to the spirit of nature-study, to shoot the birds in order to study them. It is not absolutely necessary to have a museum full of birds. Instead, observe the living bird, in its free state. The opera-glass and field-glass are used by many students to bring the birds nearer.

Mrs. Florence Merriam Bailey, who has done so much to popularize bird study, gives the following directions to observers of birds in her "Birds Through an Opera-Glass," a delightful little volume:

First.—Avoid light or bright colored clothing. Wear clothing that will blend with the background.

Second.—Walk slowly and noiselessly.

Third.—Avoid all quick, jerky motions. Raising the opera-glass too suddenly will scare away many birds.

Fourth.—Avoid all talking, or speak only in undertone—a most important but obnoxious rule to young observers.

Fifth.—If a bird was singing, but stops on your approach, stand still a moment and encourage him by answering his call. If he gets interested, he will often let you creep up within opera-glass distance.

Sixth.—Make a practice of stopping often and standing perfectly still. In that way you will hear voices that would be lost if you were walking, and the birds come to the spot without noticing you, when they would fly away if they were to see you or hear you coming toward them.

Seventh.—Conceal yourself by leaning against a tree, or pulling a branch down in front of you. The best way of all is to select a good place and to sit there quietly for several hours, to see what will come. Then you get at the home life of the birds, not merely seeing them wher they are on their guard.

Eighth.—Gaze. Let your eyes rest on the trees in front of you, and if a leaf stirs or a twig sways, look there for a bird.

In going to look for birds, it is important to consider the time of the

day and the weather. Birds usually follow the sun. In spring and fall you will find them in the fields and orchards in the morning, but when the sun has warmed the south side of the woods they go there; and in the afternoon they follow it across to the north side. During the heavy winds and storms you are most likely to find birds well under cover of the woods, no matter at what time of day; and then, often on the side opposite to that from which the wind comes.

One familiar with birds knows where to go to find them. Birds live and congregate in places according to their liking—places of safety and shelter, where food is plenty, where they can build their homes. Most birds like the water, and we find them near the shores of lakes and swamps, the banks of rivers and meadow brooks. Sheltered valleys, which keep off the winds, with water near at hand, attract many birds.

The cliffs, islands, and bays of the seashore abound with various water-fowl, ducks, geese, gulls, gannets, petrels, and shore-birds. Similar water-birds are found in the inland waters, feeding upon wild rice, aquatic plants and animals. They build their homes on the sedgy banks. Sloughs and swamps attract herons, cranes, coots, rails, snipes, and other waders.

Not only strictly water-birds, such as swimmers and waders, but many others are to be found about all kinds of waters. Many come for the water, many to feed upon the myriads of insects and other animals found there, others to make their homes in the inaccessible swamp. Here we find swallows, flycatchers, warblers, tanagers, kingfishers, sparrows, catbirds, bobolinks, thrushes, blackbirds, wrens, humming-birds, and many others.

Many birds are found in the open fields and near the edges of woods, such as field-sparrows, blackbirds, kingbirds,

meadow-larks, bobolinks, swallows, orioles, robins, woodpeckers, quail, grouse, prairie hens, etc.

In the woods the birds are not so abundant nor as easily seen as in more open places, but here are to be found woodpeckers, nuthatches, tree creepers, pewees, thrushes, ruffed grouse, hawks, owls, whippoorwills, tanagers, warblers, vireos, etc.

But we do not have to go far from home to find birds. The following birds are frequently seen close about the house, or in the shade trees of the streets, and in the gardens and orchards near the house: Robins, wrens, sparrows, rose-breasted grosbeaks, bluejays, kingbirds, orioles, bluebirds, woodpeckers, catbirds, blackbirds, vireos, warblers, nuthatches, brown creepers, phoebes, chickadees, juncos, snowbirds, kinglets, thistlebirds, waxwings, humming-birds, with English sparrows nesting in every available place about the house, eaves-swallows under the eaves, and chimney-swifts in the chimneys, purple martins in the bird-cots, and owls in belfry towers.

Bird study is an excellent hobby for the teacher. A good bird key, such as Chapman's "Color Key," Bailey's "Birds of the Western United States," Nuttal's "Birds of the United States," Apgar's "Birds of the United States," or Chapman's "Handbook of the Birds of North-Eastern United States," a field-glass (not absolutely necessary), a love for the birds, and a watchful eye are all that is needed for the study. One can pursue it all through life. It will afford a perennial pleasure, and add interest to every journey. Moreover, it is a hobby through which one can give to others some pleasure. For most persons are willing and eager to learn about the birds.

Bird Lessons in the Grades

The most appropriate time to study the birds is in the spring, at the time of their migration from the South. Then they are apparently most abundant and are the tamest. Moreover, their interesting mating habits can then be seen. The first robin or the first bluebird always causes a mild excitement. It is then that a series of lessons on the returning birds should be given in any grade. This study should contain enough of the structure and coloration to serve for identification. Of course the habits will form a chief feature of the work. Bring out the reasons for the subdued or the conspicuous colors, and by all means bring out well the economic value of the birds.

As with mammals, so bird study ought to be comparative, and there should be simple classification according to structure or according to habits. Even primary children can class the duck and goose together as swimmers, and differentiate them from the wading heron and bittern. Much more of this may be expected from older pupils.

For the purposes of nature-study it is sufficient to class the birds as Swimmers, Waders and Shorebirds, Scratching Birds, Birds of Prey or Robbers, Climbers, Perching and Song Birds. Avoid the technicalities of scientific ornithology, and yet try to bring out the fact of the relationship of birds.

The following list of birds is suggested as suitable for nature-study. These are, with a few exceptions, common and native to the northern and eastern parts of the United States:

SWIMMERS: Loon, tern, gull, pelican, duck, goose, swan.

WADERS AND SHOREBIRDS: Blue heron, bittern, crane, stork; coot, rail; sandpiper, snipe, plover.

Scratching Birds: Chicken, turkey, quail, grouse, prairie hen, peacock.

Robbers: Hawk, golden eagle, bald eagle; snowy owl, great horned owl, screech owl, barred owl.

Climbers: Flicker, sap sucker, downy woodpecker, red-headed woodpecker.

Perchers and Song Birds: Kingbird, crow, bluejay, common blackbird, yellow-headed blackbird, red-winged blackbird, oriole, cowbird, meadow-lark, bobolink, indigo-bird, rose-breasted grosbeak, cardinal, song sparrow, junco or snowbird, thistlebird, canary, English sparrow, scarlet tanager, barn-swallow, bank-swallow, martin, waxwing, shrike, summer yellowbird, zebrabird, catbird, house wren, brown thrasher, thrush, robin, bluebird.

Miscellaneous: Dove, pigeon, parrot, kingfisher, whip-poorwill, chimney-swift, humming-bird, ostrich.

When the birds begin to return from the South, in February or March, make a bird calendar on the black-board or in notebooks:

Bird Calendar

Bird	Date	Place	By whom seen	Remarks

The calendar may stimulate the children to make personal observations. Be reasonably sure that the birds are reported correctly. Often children and others name birds incorrectly through ignorance or careless observation.

Toward the end of the migration period the calendar should be examined, and conclusions drawn from it. Note the kind of birds that return first, those that come last. Try to make

out some relation between the birds and the food they may expect to find on their return.

Even though no regular calendar is kept of the returning birds the teacher should, as far as possible, call attention to the birds that come back and should name them for the pupils. This would be profitable in all the grades.

In the fall the southward flight of the birds should be observed. Have the children note their gradual disappearance, and what species go earliest and which last. Let the children infer some of the probable reasons for the migration. Refer to the known destinations of certain species, and let the pupils consider why they are going there. Use the map and trace out the chief migration routes as far as is known. Have the children observe the manner of migration. Do the birds fly singly or in flocks? Direct or by stages? By day or by night? Are the birds singing much? Can the young be distinguished from the old? All these observations will have to be made incidentally by the children, but they should be reviewed and summarized in a school-room lesson.

In the middle of winter inquire of the children if any birds are to be seen. Ask them to be on the lookout for a week or so and have them report all the birds seen. A list of the birds noted will probably include the English sparrow, dove, snowbird, chickadee, downy woodpecker, nuthatch, bluejay, hawk, owl, and perhaps others. Let the children find out what these birds feed upon, where they sleep, and any other interesting habits, and note their general appearance. Suggest that the children scatter food to the birds.

Some very interesting, as well as profitable, lessons may be

given on the structure of birds in general. Make a study of feathers, their structure, colors and various usès.

The wing of a bird, the bones, feathers, shapes of wings of different kinds of birds, and the power of flight form another good subject.

Fig. 11. Wing of Chicken with Quills and Coverts.

The legs and feet of different classes of birds should be studied, especially with reference to their adaptation to use and environment.

Similarly study the different types of bills with reference to the food or other purposes. Bring out the fact that the feet and the bills are among the chief features used in classifying the birds.

The nesting habits of birds should be observed by children. At the same time teach them to be kind to the birds, never to kill those that are harmless and useful, and not to rob or destroy the nests. Let them try to encourage the birds to build near their homes. Let them scatter food, expose bits of thread, wool, horse-hair, cotton, feathers, etc., for the birds to use in nest building.

Have the children observe how the birds build the nest. Where is the nest located? Thus robins nest in trees, bank-

swallows burrow into the bluffs, barn-swallows nest in barns, and eaves-swallows under the eaves of buildings. Is there any attempt made by the birds to conceal the nest? Is the nest in a safe place? Some nests, like ground-sparrows' nests, are hard to locate because they are so cunningly concealed in the grass. The oriole's nest is on a high branch almost at the tip. Does any particular species select a certain kind of tree? How about the oriole? What materials are used in the construction of the nest? Robins and barn-swallows use mud with twigs and grass. The red-winged blackbird weaves a pretty nest of the leaves of sedges and grasses in the swamps. The hair-bird is so-called from the fact that it uses horse-hair chiefly in the making of its nest. Note the difference in skill shown by different species of birds in choosing a location, and in the construction of the nest. Some birds make hardly any nest at all, while others, like the oriole and the barn-swallow, make beautiful and elaborate nests. Observe how the birds carry the building material, and how they work it into the nest. Do both mates work?

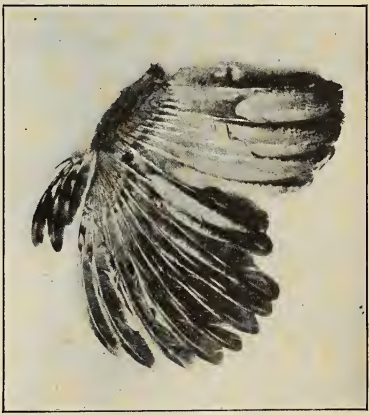


FIG. 12. Wing of Chicken.
(Wing coverts removed to show attachment of quills to forearm and hand.)

Later in the summer, when the birds are through with their nests, collect different kinds and label them properly, telling the species to which they belong. A neat way to mount them is to fix them in a wire frame on a wooden base. These nests would make a very useful addition to the school museum or cabinet, and would be very desirable in the next year's bird study. If the branches to which the nests are attached are small, the nest may be left on the branch to show the method

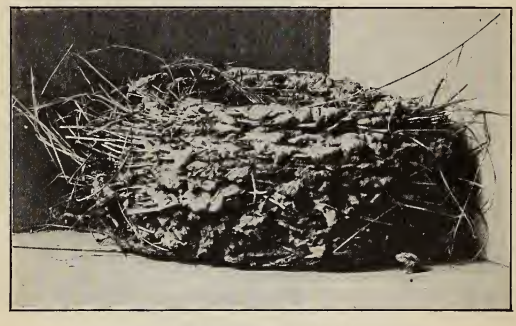


FIG. 13. Grass and Mud Nest of a Barn-Swallow.

of attachment. Cut off the piece of a log containing a woodpecker's nest, and break away a portion of the side to show the depth of the nest. If no other species of birds can be found to study during the nest-building period, the English sparrow will probably be found almost anywhere in towns. Although their nest is not a model of beauty and skill, it nevertheless shows well the activity of the birds that make it.

Examine the eggs. Do not take them out of the nest. Note the color, their number and size. Try to find out how long it takes the mother bird to hatch the eggs. Try to

accustom the parent birds to your presence after the eggs are laid, and gradually, day by day, you may be able to come a little closer for observation. Keep this up after the young are hatched. Never frighten the birds by noise or rapid motions. Some birds become comparatively tame toward those whom they have learned to trust. An acquaintance of

Fig. 14. Nest of Chipping-Sparrow.

this sort affords considerable pleasure and also an opportunity to learn about bird ways.

At this time let the children also note the songs and calls of the birds, and try to recognize them by their notes. Have them learn what time of the day the birds sing most, what birds are the best songsters, which have the power of sustained singing, which have short snatches of music, and which simply musical calls. Let them imitate these songs and calls.

Let them also study the subject of color in birds. The birds of bright and conspicuous color will interest the little children most. Let them consider these colors chiefly from the æsthetic point of view. The older pupils will be able to appreciate something of the theory that the bright coloration of birds is a mating device; that the female birds are supposed to select the handsomest males, and so the brightest colors are transmitted in the race.

But the fact should be brought out that bright coloration is almost the exception to the rule, for the great majority of species are inconspicuously colored in drab, gray, brown, or olive, so as to blend with and be concealed against the background of water, grass, or foliage. This is an interesting observation for the older children. Let them be on the lookout for birds that are protectively colored in a remarkable degree, and let them explain the adaptation in each case. Call attention to the case of the scarlet tanager, rose-breasted grosbeak, red-winged blackbird, etc. Here the male bird is handsomely and conspicuously colored, while the mate is protectively colored. Ask the children of what advantage this difference in coloration is.

In this connection, refer to the natural enemies of the birds. The reason for the protective coloration will then be clearer. Ask the children not to add themselves to the list of enemies.

Another interesting subject and one on which observations are readily made is the way in which the old birds care for the young. Note how solicitous the parents are for the young. Observe how hard they have to work to satisfy the hungry mouths. Count the number of trips the parents make with food in a certain time, say an hour. From this the

pupils would get a good idea of the task of feeding. Also let the children observe, if possible, what the young are fed with. In this way they will get an idea of the usefulness of birds as worm and insect exterminators.

Discuss with the pupils the economic importance of birds.

Fig. 15. Nest of Wood Thrush.

Tell about the experiments and investigations made by ornithologists of the United States Department of Agriculture, and by other bird students, which show the great usefulness of birds to the gardener, fruit grower, and farmer, in ridding them of many troublesome insect pests. Even if a bird does take a little fruit or does some other harm, it should be credited with the good it does. Counteract the prejudice that many have toward certain birds which, on the whole,

are really useful, yet are generally killed. For example, hawks and owls have a bad reputation with the farmer and others, as chicken and turkey thieves. But it has been shown that most hawks and owls destroy much more harmful vermin than chickens. Try to get the children to appreciate the birds as our friends and helpers, and to wish to protect rather than destroy them.

Note how the young learn to fly. First observe the growth of the plumage on the nestlings. What are the birds covered with when first hatched? Where do the feathers first appear? How long before the young are full fledged? Do the old birds seem to show the young how to fly? It often happens that some of the young are frightened or crowded out of the nest before they are really able to fly. If fairly well fledged, it is probably useless to return the waif to the nest, as it will probably fall out again. These helpless birds are easy victims to the weather, cats and dogs, and bad boys. Here would be an opportunity to help. Catch the young bird, scaring and chasing it as little as possible. Wait till it goes to sleep at night, if possible, then pick it up and place it in a cage. It will probably not know enough to feed itself, and will have to be fed by hand on insects and worms. If the cage is placed where the old birds can see it, they will often come and feed their child. Hand-feeding of young birds is not an easy task, but the patience and diligence would be rewarded by having a tame bird. After the bird is tame it should be liberated. It will probably remain about the place, and will be a greater pleasure than if kept in confinement.

CHAPTER IX

BIRDS

Birds are *feathered* creatures. This is a sufficient definition. Flight is generally associated with the thought of birds, but this power is not peculiar to them, for many other creatures besides birds fly, such as insects and bats, and formerly there were reptiles that flew. Flying squirrels, flying fishes, and flying toads soar on membranous expansions of the skin. But none of these animals fly, like the birds, by means of feathers.

The feet of loons, ducks, and geese are covered with a scaly skin, reminding one forcibly of the skin on the feet of a turtle. In the lower orders of the birds these scales are small and reptilian, but they coalesce more and more into larger and more horny plates as we go up the scale, till in the robin and bluebird the tarsus is covered with a continuous plate along the front.

The homology of a bird's wing is instructive. In general, it corresponds to our arm. The quill feathers are attached to the forearm and to the hand. The bones of the latter are generally grown together and unjointed, the thumb alone being free.

The leg bones also correspond to those in the mammal. The prominent bone, usually unfeathered, is the tarsus or ankle bone, the heel being just above it. The knee bends

forward, and is between the tibia ("drumstick") and the femur ("second joint"). The latter is generally not conspicuous in a feathered bird and is often within the body.

The feet of birds are varied and wonderfully adapted to their habits. Swimmers have webbed paddle feet, shore and marsh birds have partially webbed feet, or their toes are bordered with lobes or membranous margins that enable them to walk on swampy ground. Birds of prey have powerful grasping feet with long, sharp, and curving claws, adapted well to seize and carry off their prey. Perching birds have three toes in front and one behind, which are admirably suited to grasping a limb. The grasping is automatic, and the bird when asleep on the perch is in no danger of loosening its hold and falling off. Woodpeckers that run up the side of a tree and have to cling there while pecking into the wood have strong feet with two toes in front and two behind. Birds, like the chicken, that scratch for a living have the hind toe somewhat raised and shorter than the others. This is probably to keep the hind toe out of the way while scratching.

The bills of birds are as varied as their feet, if not more so. They are beautifully adapted to the food and feeding habits of the bird. There are the strong hooked beaks of the hawks and owls, well suited for holding and tearing the prey; the strong conical bills of the seed and grain eaters, for picking and shelling the seeds; the more slender and softer bills of the insect-eating birds; the long, slender bills of storks and herons, well adapted for work in the swamps and edges of ponds; the long and often touch-sensitive bills of the shore birds which poke around in the mud for their food; there are strainers for the ducks; pouched beaks for

pelicans; hard ivory-tipped bills for the wood-boring woodpeckers, etc.

The technical classification of birds is based more upon the structure of feet and bills and internal structure than upon color, size, or habit, although, of course, these are also used.

Feathers are skin modifications, as are scales and hair. They serve a variety of purposes. The downy underfeathers are the warm underwear. We utilize them for pillows and warm feather-beds. Feathers are non-conductors of heat, and thus keep in the heat of the body; but the air included between the feathers also acts as a non-conductor. On cold days the birds may be seen ruffling up their feathers so as to include more air, thus utilizing the principle of the "dead air space" which we employ in our storm-windows. Birds that live in the water have their bodies more thickly covered with down than other birds. Nestlings and precocial birds, like young chickens, have another kind of down. This is pushed out as the real feathers develop. There are also slender hair-like feathers, called pin-feathers, which the cook singes off the fowl. These are rudimentary feathers with only a shaft.

The plumage feathers cover the down feathers and add to the warmth. In some birds, as in the owls, the plumage feathers are very soft and render the flight noiseless. But in most birds the chief function of plumage feathers seems to be to give the coloration—for beauty or for protection. These feathers in nearly all kinds of birds do not cover the whole body, but grow in distinct tracts, yet overlapping the bare areas.

On the tail and wings are long stiff feathers, called quills, which are used in flying. These may be taken as typical.

They consist of a hollow quill stem and a solid elongation, the shaft. On the shaft at each side are fine branches called barbs. These are again divided, and sometimes subdivided into smaller branches called barbules and processes. These barbules and processes interlock to form a stiff, resisting surface. The shaft and barbs form the vane.

Fig. 16. Chimney Swift.
(Not a swallow.)

Besides these feathers there are various modifications in different birds, such as the beautiful plumes on the heads, chest, shoulders, hips, etc., of ostriches, herons, and other birds; the hair-like tuft on the breast of the turkey cock, etc. These are used mainly for decoration.

Birds raise and maintain themselves in the air not by their relative lightness (as is the case with a balloon), but by the reaction of the air against the powerful wing strokes, or else by the force of winds against the wing and tail surfaces. Most birds that flap their wings in flight use the first principle, while the hawk, which circles around high in the air without apparently a stroke of the wing, and only

occasionally tilting the wings and tail to better catch the shifting breezes, uses the latter method. Most birds fly mainly by strength, but the hawk, eagle, and albatross fly by skill; that is, they soar on the wind without much muscular effort.

The wing of a bird is suited to its peculiar needs. Gulls, hawks, and swallows, much on the wing, have large wings, and chiefly soar. The robins, sparrows, blackbirds, etc., which live mainly on the ground, or skulk about the bushes, or flit among the trees, do not need the power of long flight. They generally fly by easy stages. But they need the power of rising quickly from the ground when startled. So their wings are broad, rounded, and concave underneath, so as to resist the air well. The quail, partridge, and sparrow cause a rustling sound by the rapid fluttering of their wings on starting from the ground. The humming-bird makes its wings go so fast that you cannot see them, and the buzzing of the wings gives it its name. Birds of long wing, like the duck, gull, and albatross, cannot rise well unless they run or swim quickly on the level till they get the necessary speed to enable them to rise on the air.

Strange as it may seem, because one of the chief distinctions of birds is flight, there are some birds that have given up the habit of flying, and by disuse the wings have become rudimentary or have degenerated into organs for other purposes. This degeneration is greatest in the cassowary, emu, and apteryx, which have almost no wings at all. The ostrich has rudimentary wings unfit for flight, but which are still flapped while running. These birds depend upon their legs for escape. The penguins are marine birds, chiefly in arctic waters, which use their wings as flippers in swim-

ming. The wings are destitute of feathers and are covered with scales like the feet. The wings seem to be the main swimming organs, the feet being used more like rudders.

Many birds add a touch of brightness to the generally subdued or sombre colors of nature. Especially those of the tropics are strikingly and beautifully colored with bright hues. The oriole, robin, bluebird, bluejay, rose-breasted grosbeak, goldfinch, tanager, indigo bird, woodpecker, red-winged and yellow-headed blackbird, cardinal, summer yellowbird, redstart, meadow-lark, some of our wild ducks, especially the teal and the wood-duck, are the most common of our birds which have conspicuously other colors than black, white, brown, or gray. The colors of the great majority of birds are subdued and inconspicuous. Probably no other animals have such excellent protective coloration. Most birds are colored so as to blend with the background. Field and ground birds like the great sparrow tribe, snipes and sandpipers, quail and grouse, are seen with difficulty when standing or sitting motionless in the grass, leaves, sand, or marsh. Hunters know that quail cannot be seen though sitting within a yard's distance, and that these birds rely so much on their mimicry of the ground and leaves that they will not fly up until almost stepped on. A ruffed grouse may be disturbed with her young, but at a sudden warning from the mother the little birds scatter, and in a trice are effectually concealed by crouching among the dry leaves and sticks on the ground. Arboreal birds, such as warblers, vireos, creepers, and thrushes generally, have brown, gray, or olive colors, so that it takes a sharp eye to see them among the leafy trees and shrubbery. The whip-poor-will not only mimics the bark of the trees, but sits

lengthwise on the branch so as to mimic more completely the appearance of a bend or a knot on the branch. The bittern is of a tawny color streaked lengthwise with black, so as to look like the light and shade effect among the slender marsh grasses in which it lives, and when surprised it stands still, pointing its bill upward so as to make all the lines of the body vertical like the grass. Even the contrast between the darker backs and the lighter bellies of so many birds is for rendering the bird more inconspicuous. The artist, Mr. A. H. Thayer, has shown that the lighter underside makes the shadows under the bird less dense, and thus makes the bird stand out less from the background.

Some birds, as the ptarmigan, the snowy owl, and the white snowbird, change their plumage colors summer and winter. They become almost pure white in the latter season, so that they are almost indistinguishable against the snow.

But brightness of color is dangerous to a bird. James Lane Allen shows well in his sympathetic study of the Redbird in his "Kentucky Cardinal" what the dangers are: "I am most uneasy when the redbird is forced by hunger to leave the covert of his cedars, since he on the naked or white landscapes of winter offers the most far-shining and beautiful mark for Death. . . . For it is then that his beauty is most conspicuous, and that Death, lover of the peerless, strikes at him from afar. . . . Let him show his noble head and breast . . . and a ray flashes from him to the eye of a cat; let him, as spring comes on, burst out in desperation and mount to the tree-tops which he loves, and his gleaming red coat betrays him to the poised hawk or to a distant sharpshooter; in the barn near by an owl is waiting to do his night marketing at various tender meat-stalls; and, above

all, the eye and heart of man are his diurnal and nocturnal foe."

The origin and development of bright colors is believed by some authorities to have something to do with the mating of the birds. Some say that the female chooses for a mate the male that shows the handsomest colors, and that these colors are then transmitted to the next generation. At any rate these fine colors are put on only during the mating season, or are at their brightest during that period, and hence we may call them the matrimonial clothes. The rooster, the peacock, turkey, and other gaily-plumaged birds show their finery to their admiring female friends.

In the mating season there are developed in some birds curious crests, plumes, waxtips on the wing feathers, excrescences on the bill, etc., all of which may be considered as frills of fashion.

> In the Spring a fuller crimson comes upon the robin's breast;
> In the Spring the wanton lapwing gets himself another crest;
> In the Spring a livelier iris changes on the burnished dove;
> In the Spring a young man's fancy lightly turns to thoughts of love.
>
> —Tennyson, *Locksley Hall.*

The mate of brightly colored males is less bright as a rule. The female robin, oriole, and bluebird are considerably more subdued in color than the males. The female rose-breasted grosbeak, red-winged blackbird, and scarlet tanager are not at all like the handsome males in color, but are dressed in rusty brown or olive. This is a sacrifice of finery to safety. If the female had the bright colors she would be seen more easily on the nest, and after the young were hatched would be exposed to many dangers from predatory enemies. This

would also mean the destruction of the young. The bright colors of the males may have been developed as suggested, or the brightest females may have always been most frequently destroyed and the less conspicuous ones escaped, and thus the subdued colors developed. This is probably not the whole explanation of the difference in color in the sexes.

Birds moult, that is, lose their feathers wholly or in part every year, or even several times a year. This loss of feathers has some connection with the putting on of mating colors and decorations, and sometimes is for protection. Change of plumage colors is chiefly due to moulting and renewal. But the pigments in the feathers may change, and sometimes the tips of the feathers wear away and the lower ends of the feathers with a different color are exposed. This last is the case with the house sparrow when the male puts on his black bib in the spring.

The young are generally not quite of the same color as the adults, though full fledged. The colors and markings are not as bright or as distinct. Sometimes there is a great difference in color or marking, as in the young robin, which has its breast mottled with brown spots, like a thrush, revealing the connection of the robins with the thrushes.

The colors in feathers are chiefly due to pigments. But the changing iridescence displayed on the feathers of the dove, blackbird, humming-bird, etc., is due to the interference of light rays reflected from the surface of the feathers—analogous to the iridescence on the mother-of-pearl.

Besides color, there are other mating devices. Many male birds go through curious and, to us, comical performances before their lady-loves. We have all seen the strutting, rustling, and spreading and snapping of feathers by the

turkey-cock. The ruffed grouse does a similar thing, and makes a drumming noise with his wings by flapping them against his sides. A common sight is the clamorous attentions bestowed upon a female sparrow by several chirping, dancing males at the same time, all spreading their wings like little turkey-cocks—each apparently saying, "Take me, take me!" Sometimes the males engage in fierce combat over a mate, the victor winning the female which was the cause of all the trouble.

The most cheering thing about birds is their song. This is a general statement, for many, probably the majority of birds, do not sing, though they may make sounds. But certain species have become great artists in song.

The canary, European lark, nightingale, and the mocking-bird have the reputation of the greatest artists. They have the power of prolonged singing, and at the same time their notes are exquisite and true. The catbird will sing by the hour, and the brown thrasher and the robin also sing at length; but their song, though cheerful and entertaining, is less excellent. Other birds, such as the song sparrow and the bobolink, sing short bursts of sweet melody. Thrushes, bluebirds, meadow-larks, vireos, and warblers have short, sweet songs. With other birds the song is still more reduced, only one or two syllables of music, as in the case of the tow-hee, bobwhite, phœbe, etc. The lower birds, swimmers and waders, do not, as a rule, sing. Yet they have their calls.

Why do birds sing? Probably the earliest function of the voice was to call the mate, or the young, or companions. It is still so used. But the song, no doubt, is meant at times to please, to serenade and cheer the mate. Oftentimes the song is simply a joyous overflow of spirit and energy—the

bird is glad it is living. Birds, in singing, usually select some elevated place, the tip of a reed, or the top of a tree, to suit their elevated spirit. Some, like the skylark, fly skyward higher and higher, singing the while, till almost out of view. Birds also sing out of mere rivalry, or as a challenge. This is well illustrated in our barnyard cock, which answers defiantly the crow of another perhaps distant cock. Many birds have the same note for calling, scolding, distress, fear, and rejoicing. Others express different emotions by a variety of sounds or songs.

Birds sing most in the mating season, in the spring, but after the hungry brood appears the father finds little time or inclination for singing. Some birds take to singing again in the fall, but not so much as in the spring.

Birds sing chiefly at sunrise and during the early hours of the morning, and are quiet in the middle of the day. The robin, mocking-bird, and others give us evening songs. The vesper sparrow is called thus because of its evening serenade. Nightingales and mocking-birds sing even after sunset. Nocturnal birds, of course, are heard at night. Then are heard the hoot of the owl, the squawk of the nighthawk, and the plaintive call of the whippoorwill.

It is difficult to express in human sounds the songs of birds. Many names have been given on account of fancied resemblance of the calls or songs of the birds to the names given, thus chewink, chicadee, whippoorwill, pewee, bobwhite, etc. Different observers interpret the more complicated songs in different ways according to the mood awakened by the song or according to the mood when the song was heard, hence no two interpretations are alike. Mrs. Bailey, in "Birds through an Opera-glass," says the robin sings "Tril-la-ree,

tril-la-rah," repeated. She says that little German children think the bobolink says, "Oncle-dey, dunkle-dey," while the farmer's boy believes he says, "Dig a hole, dig a hole, put it in, put it in, cover't up, cover't up, stamp on't, step along," and therefore calls him the "corn-planting bird."

Nests and Nestlings

There is a great difference in the kinds of nests and in the skill shown by different species in nest construction. Some birds build no nest at all. There are many sea fowl which lay their eggs on the bare rock. The whip-poorwill lays hers among the dead leaves on the forest floor. Her cousin, the night-hawk, lays hers on the flat roofs of city buildings. Many ground birds, such as quail, chicken, and "partridge," make hardly any pretence at nest building, but lay the eggs in a shallow depression hollowed out by the breast among the leaves or in the ground. Many ground-nesting birds lay eggs that are colored like the leaves and earth, and are therefore more likely to escape notice. The ground nest is usually more or less concealed by a clump of grass, weeds, a bush, log, or base of a tree. Being made of leaves or grass, the nests are hard to distinguish from the background. The

FIG. 17. Robin's Nest.
(Showing method of mounting. Materials—grass, twigs, mud.)

nests of ground sparrows are especially well hidden among the grass or weeds, and one may almost step on such before the bird will fly off and be seen, and even then the nest may not be easily found.

Probably for greater safety from weasels, foxes, snakes, and other foes the birds first took to building in trees and bushes. Most such nests are perched in the crotch of a tree or shrub, although some, like the humming-bird and sometimes the robin, will saddle the nest on top of a twig or a bough. Some, like the vireos and orioles, suspend their nests from the branches. Among tree dwellers we find some hawks, owls, and eagles, the crow, mourning dove, robin, kingbird, bluejay, blackbird, grosbeak, cedarbird, wood thrush, catbird, many warblers, and some sparrows. Some birds seem to prefer special kinds of trees. The robin has a liking for box-elders and maples, and the oriole a fondness for the drooping branches of the elm.

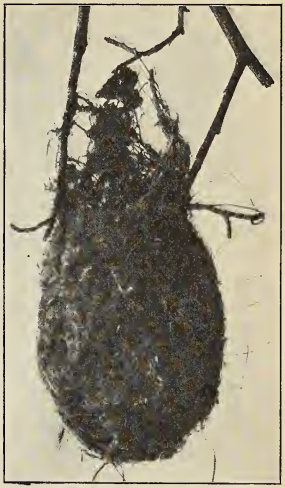


Fig. 18. Oriole's Nest.
(Hair and fibre interwoven into a hanging basket.)

Most song birds use small twigs, grass, fine fibrous roots, bark fibre, and hair for the material of the nest. Many plaster this material together with mud or clay. This is seen well in the robin's, the phœbe's, and the eaves-swallow's

nests. The coarsest material is placed on the foundation and at the outside. Many birds put a lining of horse-hair or feathers on the inside of the nest. The eider duck's nest is chiefly of feathers plucked from the breast of the mother, and, when the nest is left, the eggs are carefully covered with feathers.

The various materials are carefully woven together, the bird using its bill for the purpose. Even the mud is carried in the bill. The general form of the nest is moulded by the bird's pressing the material into shape with its body. Watch a robin building a nest, and you will see the bird frequently squatting down and turning about in it to give the materials the desired shape.

Birds often display considerable ingenuity and discretion in the choice of a location for the nest. Some seabirds, on inaccessible islands and cliffs, do not need much of a nest for the protection of the eggs and young; but where enemies are liable to intrude, the nest must be made inconspicuous or placed in a safe location. The red-winged blackbirds, marsh wrens, and bobolinks find safety by building in the swamps and marshes. The first makes a large, loose nest of marsh grasses, woven together and fastened to reeds or cattails.

A number of birds live in hollows in trees or stumps, as the wren, flycatchers, nuthatches, brown creepers, chickadees, and bluebirds. Woodpeckers dig out their own hollows in dead trees by means of their stout chisel beaks. Their nest is lined only with wood chips. Owls are often found in large hollows in decayed trees.

The crevices and ledges of cliffs are selected by many birds, especially on the seacoast by sea-fowl. Phœbes and cliff swallows also lodge in such places.

The kingfisher and bank-swallow dig tunnels into the sides of clayey or sandy bluffs, at the ends of which they make their nests.

A wonderful nest is that of the eaves-swallow, which is found under the eaves of barns and houses. This is a flask or cup shaped nest made of pellets of clay plastered together and lined with feathers.

The chimney-swift makes a pretty little shelf of sticks

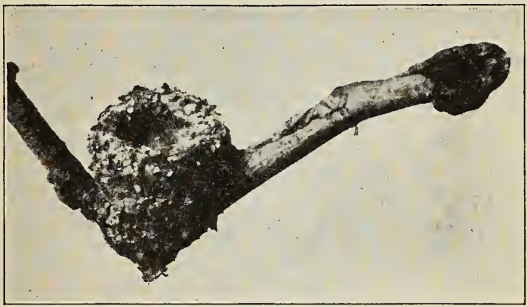


FIG. 19. Nest of Humming-Bird.
(Built of lichens. Simulating a wart on the twig.)

which it cements together with a sticky saliva and attaches to the inside of unused chimneys.

One of the daintiest nests is that of the humming-bird. This is a tiny thing composed of moss and fibres plastered over with lichens and lined with cotton. The nest is cemented on top of a branch, and so cleverly imitates a knot that it easily remains unnoticed.

The Baltimore oriole's nest is beautiful in workmanship, and is safely and airily suspended from the end of a drooping elm branch, where neither snake, squirrel, nor small boy

dares to venture. Occasionally other trees, soft maples and tall cottonwoods, are selected for the nest. It is composed of a network of bark fibres, grasses, hair, and threads skilfully woven together into a little sack or swinging basket, and is hung below the branch.

The little house wren will build in almost any sort of cavity, a knot-hole in a tree, a deserted woodpecker's nest, a hollow gourd suspended on poles or walls, even old boots and coat pockets. The house wren is very easily attracted to our homes by placing a bird-house on some shady wall or on a tree. The hole should be rather high up and not more than one inch in diameter. Here is a picture of the inside of a wren-box. It is more than half filled with coarse sticks and twigs, some six or eight inches long, which the bird knew enough to take in endwise. Finally, a few feathers and some cottonwood down were added for lining.

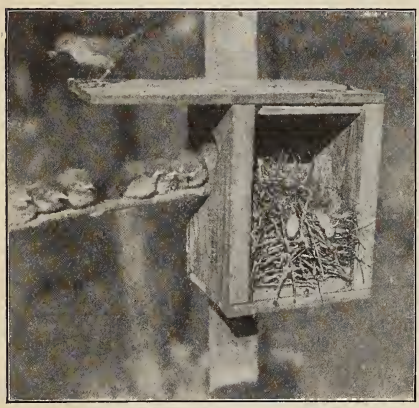


FIG. 20. Wren Box, Side Removed.

The nesting habits of the house sparrow are easily observed. It builds in sheltered nooks about the house, over cornices, mouldings, in drain-spouts, and in holes in the walls or roof. The nest itself is not very elegant, being

hardly more than a loose pile of straw, sticks, grass, and feathers. It is sometimes quite large, often causing trouble with drains, and looks unsightly on the house. For this reason many people destroy the nests. The birds frequently rebuild several times before becoming discouraged.

Some grebes make a floating nest of rushes and sedges which they fasten to growing stems of water plants.

The cowbird builds no nest of her own, but lays her eggs in the nests of other often smaller birds. The foster parents hatch and rear the young cowbird. Most writers on this subject say that the parent cowbirds pay no attention whatever to the young. But Mr. Mason, in "A Hermit's Wild Friends," asserts that he has frequently seen the mother of the young cowbird visiting the nest where her offspring is quartered, and occasionally has seen her feed it, and that, when finally out of the nest, she assumed full care of the young bird.

There are two kinds of nestlings, precocial and altricial. The former are down-covered at birth and are able to run about or swim, and in a measure take care of themselves and feed alone. Domestic chicks, young turkeys, ducks, and goslings belong to this class, and also quail, grouse, and wild waterfowl. But most birds are born far less advanced. They are naked or almost so, weak and helpless, and remain for a time in the nest, and are taken care of and fed by the parents. This is generally for a period of several weeks, till they are able to fly. For this reason a good, well-concealed nest is an advantage. The featherless and helpless state of this class of young birds is seen well in the case of the canary. Young robins, blackbirds, woodpeckers, thrushes, sparrows, etc., are like this. It is interesting to

watch the development of the nestlings. At first ugly and nearly naked, they become covered with down, and then later the real feathers appear, first on the shoulders, wings, and tail, and later on the rest of the body. The colors of the young, even when fully fledged, are not quite like those of the old birds, are less distinct in marking and less intense.

Watch the old birds feed the young. They seem almost always hungry, and keep their parents very busy, bringing worms, insects, fruit, grain, etc. Professor Treadwell records that a young robin requires its own weight of insects daily. The parents have been timed to carry food as often as once a minute to the young. The infant diet, even of seed-eaters like the sparrows, is at first almost wholly insects and worms. After leaving the nest the young still receive some care from their parents. The robins, blue-jays, grosbeaks, and sparrows may be seen in the yards and on the lawns, feeding the big babies that have left the nest and can fly almost as well as the old ones.

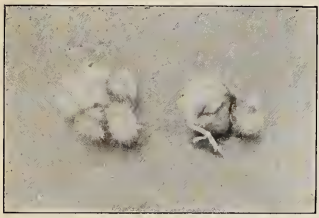


FIG. 21. Young Grosbeaks.

Migration

Most of our birds migrate to milder climates as the cold weather of autumn approaches. The increasing coolness of the weather and the decreasing food supply, especially insects, are probably the chief reasons for migration, though there are probably other influences that impel the birds to take up their yearly pilgrimages. Migration habits are in-

teresting and easily observed. Many birds gather in flocks, sometimes of very great size, preliminary to migrating. Blackbirds congregate and fly in vast armies sometimes miles in length. Bluebirds and robins go in smaller parties, and by shorter stages, resting here and there on the way. Ducks and geese fly in marshalled flocks, and probably in longer flights, although even they stop on the way in our northern lakes. Many birds disappear quietly without attracting any notice, except that they all seem to be gone, when we think of them. Some fly by day, as the above mentioned, others in the night, as is known by their disappearance between days, and also from the observations of lighthouse-keepers.

Where do the birds go? Many do not go further than the Middle and Southern States. The bobolink, which is found only in pairs here and there in the meadows in the North, collects in great armies on its way and spends the winters in the southern rice-fields along the coast of the Gulf. The robins also go here for the winter. Some of our birds go to Mexico, and even to South America. Some fly across to the West Indies.

It seems probable that birds are guided in their travels by more than the sense of sight. They have a good sense of direction, and often fly across the sea in foggy weather without losing their way. Different species choose different routes of migration. Sea fowl generally travel along the coasts. Some of the land birds travel along the Atlantic Coast and then fly across from Florida to the West Indies, and from there to the shores of South America. Their route seems to be governed by the food supply. For most of the species that fly *via* the West Indies do not use the Lesser Antilles as stepping-stones, as here the food supply would

not be sufficient for so many birds. Others go to Mexico and South America by flying over the mainland and the Isthmus, while still others fly from the Gulf States across the Gulf, and not necessarily at its narrowest part either. This shows that some birds are not averse to long flights over the water. In their migrations birds are subject to many dangers. Along the coast they are attracted by the lighthouses at night, and beat themselves to death against the shining beacons. Storms, rain, sleet, and cold often destroy thousands of them. Many flocks are exhausted and drown in the seas they attempt to cross.

Mr. W. W. Cooke writes in the 1903 "Yearbook of the United States Department of Agriculture" of the Eastern nighthawk migrating 5,000 miles from Alaska to Patagonia, and the American golden plover going from within the Arctic Circle to the southern part of Argentine, a distance of 8,000 miles. He also gives interesting estimates of the rate of travel. The average speed in the northward migration in the spring from the Southern States to Minnesota is about 23 miles per day, increasing more and more after this, to 40 miles through Minnesota, and to 70 or more miles farther north. The reason for this increase is that the season advances more rapidly farther north. He states that most birds that winter south of the United States outstrip the spring in its advance, but that the robin advances more slowly than spring.

In the warm South the birds spend the winter and enjoy themselves. But on the return of spring they go north to breed. Northern latitudes seem better for the breeding, and many birds build their nests far north in Alaska, the Mackenzie Valley, Labrador, and even in Greenland. The

return is sometimes made in great flocks that distribute themselves gradually over a wide territory. Sometimes the flocks are small. Sometimes the flight is direct, and sometimes by short and easy stages. In the spring we frequently notice the appearance of flocks of robins and other species, which suddenly disappear, probably having passed on farther north. In a number of species the males come first. Individual, marked birds have been positively known to return to the same summer home year after year.

In mild winters some of the birds of passage do not go south, but remain with us. Crows, robins, flickers, song-sparrows, bluebirds, etc., have been observed in the North in winter.

There are certain birds that stay with us in the northern part of the United States all the year. Owls and hawks, quail and grouse, downy woodpeckers, nuthatches, chickadees, bluejays, English sparrows, snowbirds, and others remain with us to enliven the wintry landscape. They find a living in the seeds of weeds and grasses that project above the snow, or in buds, berries, and nuts on trees and shrubs. The eggs, larvæ, and chrysalides of insects found on the bark of trees also supply a large part of the winter food. The birds of prey catch smaller birds and small mammals.

The Food of Birds

The food of birds depends upon the species, upon the mode of life of the bird, and upon the food conditions. Birds are either predominantly vegetivorous or insectivorous, some eating the flesh of other animals. But most of the first class will also eat insects, and vice versa.

The vegetable diet consists of seeds, fruits, nuts, grains, corn, buds, leaves, and sap.

A large number of bird species feed upon the seeds of weeds, such as ragweed, pigweed, the buckwheat family, hemp, mullein, and wild grasses. The great group of sparrows especially eat the seeds of weeds. So do the blackbirds, cowbirds, bobolinks, quail, grouse, pigeon, and wild ducks.

Cultivated grains are eaten by crows, jays, blackbirds, pigeons, prairie chickens, ruffed grouse, quail, sparrows, meadow larks, bobolinks, ducks, and geese. Nuthatches, woodpeckers, crows, jays, pigeons, blackbirds, grouse, and quail feed upon corn.

Wild rice in the swamps is a favorite food with many birds, especially red-winged blackbirds, bobolinks, rails, and wild ducks. The same birds commit great havoc in the southern fields of cultivated rice.

The dry seeds or fruits of many trees are relished. The white elm nutlets, the fruits of birches and maples, and the seeds of conifers (especially pine) are eaten by finches, sparrows, woodpeckers, chickadees, and nuthatches. They constitute, with the seeds of weeds, the chief winter diet of many birds.

Nuts are eaten by crows and bluejays, which peck them open. But the pigeon, grouse, ducks, and quail shell them in their gizzards.

The dried fruits of the sumach, bayberry, rose, Virginia creeper, grape, and barberry, that remain on the winter shrubbery and vines, afford food for the winter residents—chicadees, nuthatches, sparrows, snowbirds, jays, and crows.

There are many birds that relish juicy fruits, and in the ripening time they sometimes do damage to fruit and berry plantations. The catbirds, brown thrashers, robins, sparrows,

quail, grouse, cedar birds, orioles, blackbirds, flickers, bluebirds, crows, and others like fruit. But most of them seem to prefer the wild fruit, such as choke-cherries, wild grapes, raspberries, blackberries, partridge berries, barberries, blueberries, huckleberries, elderberries, Virginia creeper, mountain ash, and cranberries.

In the winter and early spring quail, grouse, sparrows, and

FIG. 22. A Weedy Cornfield.
(The feeding ground of many birds in autumn and winter.)

grosbeaks eat the buds of trees and shrubs. Grouse, ducks, and geese also eat leaves of shrubs and herbs.

The yellow-bellied woodpecker, also called sapsucker, is so called because he taps maple and orchard trees for the sap. The chickadees and kinglets, also, will drink the sap of wounded trees.

The animal diet of birds consists primarily of insects, also of spiders, thousand legs, snails, angleworms, crayfish,

fish, frogs, toads, lizards, and snakes, while the larger birds feed upon the smaller mammals and birds. Practically all birds, even the little nectar-loving humming-bird, will include insects on their bill of fare. Some birds, like the wrens, swallows, tanagers, swifts, nighthawks, warblers, and vireos, are almost exclusively insectivorous. Thrushes, catbirds, robins, bluebirds, woodpeckers, chicadees, bluejays, brown thrashers, cowbirds, cedar birds, orioles, brown creepers, rose-breasted grosbeaks, kingbirds, phœbes, and many shore birds feed chiefly upon insects.

The Economic Value of Birds

One thing should be emphasized in bird study, and that is the "dollar and cents" value of birds. Man has a much greater material interest in the birds than in their song and beauty and lively ways. Our forefathers snared and shot with bow and arrow the game birds, and we hunt them still. Canvasback ducks, prairie chicken, and quail on toast are delicacies of food.

Long ago man captured the jungle fowl, wild goose, and wild duck, and more recently the wild turkey, and has domesticated them all. From them we have derived the great variety of our domestic poultry. Poultry may be considered as domesticated game. The chicken industry alone is very large in this country. The estimated production of eggs in the United States is about 2,000 million dozen, which at only fifteen cents a dozen would amount to $300,000,000. To this should be added the dressed poultry of the meat markets and the down of geese and ducks.

The eggs of many wild birds, particularly seagulls, are gathered in boat-loads on the sea cliffs and rocky isl-

ands along the coasts, and used for food and other purposes.

Ducks and geese furnish us with soft pillows and downy beds. The finest down comes from the nests of the eider duck along the far northern sea coasts. This duck lines

Fig. 23. Feeding the Chickens.

her nest and covers her eggs with feathers plucked from her breast.

Man, or rather woman, has borrowed the plumage of birds for personal adornment, and an immense trade flourishes in ostrich plumes and the feathers of many other birds.

As a minor economic item, may be mentioned the catching and sale of song and pet birds, such as the canary, mocking-bird, and parrot.

Mention should also be made of guano, which is a very valuable fertilizer, and is the accumulated manure of sea birds found on many islands in dry climates, especially off the Peruvian coast.

Another economic aspect of the birds is seen when we consider the harm that certain birds do. Many species entail a loss to man by injuring his crops, or feeding upon his fruits, or by robbing him of domesticated animals or of game. Blackbirds and crows are great grain and corn thieves, and when they gather in flocks of thousands in a farmer's field, they do great damage to the freshly sown grain, or dig up the planted corn, or shell out the heads of the standing crop. When troublesome this way they are deservedly shot. The bobolinks, so famous in poetry and so harmless and cheering in the North, become a veritable pest in the southern rice fields, where they spend the winter in vast flocks. Here they are shot and eaten by the negroes and others. The cedarbird, catbird, thrush, and robin do considerable damage to small fruit, such as cherries and berries. The Baltimore oriole has a bad habit of pecking open the pods of green peas. Farmers and gardeners try to protect themselves by shooting the thieves or by setting up scarecrows, which, however, are generally useless. Crows, hawks, and owls steal poultry, and occasionally they thus cause great annoyance.

On the other hand, practically all birds feed upon insects, and many destroy other harmful creatures or such as are considered a nuisance. In this way man derives a great indirect benefit from the birds. This is not realized as thoroughly as it should be, or it is often forgotten, while at the same time only the sins of the birds are remem-

bered against them. Some one sees a sapsucker bleeding an apple tree, and perhaps injuring a limb. Immediately the orchardist places the bird upon the harmful list and makes war upon it, forgetting the good this bird does in ridding his fruit trees of harmful borers, beetles, plant lice, etc. Teach the children to suspend judgment on the birds, and not to condemn them immediately as unmitigated pests. If a cedarbird takes a little fruit, it does still more good by destroying noxious insects. Let the fruit taken be considered part payment for the good done. The economic importance of the birds can only be determined by averaging the good and the harm they do. This is found out by a careful study of the feeding habits of the birds. Investigators of the United States Department of Agriculture and others, such as Beal, Judd, Forbes, Fisher, Weed, Dearborn, etc., have shot many thousands of birds of different species in different seasons and have examined the contents of their stomachs. From such observations we are able to say more accurately whether a bird is on the whole useful or harmful.

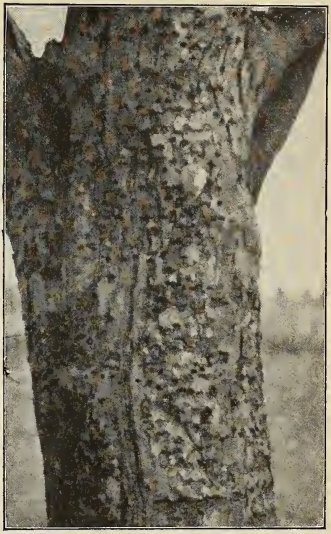


FIG. 24. Apple Tree Showing Good Work of Woodpeckers Hunting for Borers.

Thus we can say that the goshawk, the sharp-shinned hawk, and Cooper's hawk do more harm than good, but that the other hawks are on the whole beneficial in destroying harmful field vermin; that the great horned owl is about as useful in destroying field mice, rats, gophers, moles, frogs, etc., as he is harmful in stealing chickens and in killing quail, grouse, and song birds; and that the bluejay is not such a thief and cannibal as he is generally thought to be. Most bird students agree that the English sparrow has proved a curse instead of blessing to this country. He does not pay for the grain he eats, nor for the beneficial birds he drives away, nor for the general nuisance he makes of himself around our houses.

We know that the woodpeckers and warblers keep our trees free from borers, caterpillars, plant lice, etc.; and that cuckoos and flycatchers, meadow larks, orioles, swallows, wrens, robins, and bluebirds are almost wholly beneficial. They feed almost entirely upon injurious insects and worms. We know that the wild sparrows, such as the song, chipping, tree, field, and other sparrows, and the slate-colored junco are very useful in eating great quantities of weed and grass seeds. Professor Beal estimates[1] that in Iowa alone the single species of the tree sparrow destroys at least 875 tons of weed seed. And Mr. Judd estimates[2] that the bobwhites in the State of Virginia annually destroy 573 tons of weed seeds. This gives a good idea of the usefulness of some of our birds.

Birds are the natural check upon the too great multiplication of insects. The thrush family, the wren family, swal-

[1] "Common Birds in Relation to Agriculture," Farmer's Bulletin, No. 54.
[2] Yearbook, 1903. U. S. Department of Agriculture.

lows, swifts, warblers, vireos, flycatchers, tanagers, and the shore birds, woodpeckers, chicadees, and nighthawks are almost entirely insectivorous, and highly beneficial to the farmer, the fruit grower, and the truck gardener. They also protect our flower gardens, our lawns, and our shade trees.

Even seed-eaters, like the blackbirds, bobolinks, jays, finches, and sparrows are largely insectivorous; as are also wading birds, grouse, hawks, and owls. The food of nestlings, even of seed eaters, is at first composed wholly of soft insects, such as caterpillars, cut-worms, grubs, larvæ of ants, etc., flies, plant lice, etc. Gradually harder shelled insects, like beetles, bugs, and locusts are added, then berries and fruit, and then hard seeds. Thus even seed-eating sparrows, etc., are valuable as insect exterminators during the breeding season.

Birds feed especially upon any insects that become unusually numerous. Thus in plagues of cankerworms, army-worms, or locusts, the birds find this class of food especially abundant, and therefore subsist on it more than ordinarily. In locust years these insects are eaten a great deal even by birds not particularly insectivorous, such as owls, hawks, sparrows, and grouse. Thus, when a plague of insects occurs, the birds' activity in destroying them correspondingly increases, and acts as a very great check on their multiplication.

Mr. Forbes made an investigation during a cankerworm plague that was ruining the shade trees, to see how well the birds were doing their work in destroying this pest. He examined the stomachs of 149 birds of 36 different species, and found that 85 birds representing 26 species had eaten the worms. That is, 72 per cent. of the species, and 60 per

cent. of the birds had eaten the caterpillars. Taking the 149 birds, 35 per cent. of their food was cankerworms, a very good showing.

There is a most unfortunate prejudice against hawks and owls. An examination of their stomachs has shown that most of them are positively beneficial to the farmer and the fruit raiser in destroying gophers, rats, mice, weasels, moles, insects, etc. And yet the average man or boy feels that he is virtuously doing his duty in shooting them.

Fig. 25. Red Owl.

In the winter of 1904 field mice wrought great destruction in the orchards of Minnesota and Wisconsin. The mice gnawed the bark at the base of the young trees and killed them. Similar plagues of mice, gophers, and other small rodents have visited other states in this country and elsewhere. The only natural check seems to be larger mammals and hawks and owls. It is known that these birds are attracted to those regions where such pests abound, and destroy great numbers of them.

In 1886, the State of Pennsylvania offered a bounty on hawks, owls, minks, and weasels, and in a year and a half paid $90,000 in bounties. One hundred and twenty-eight thousand,

five hundred and seventy-one animals, mostly hawks and owls, were killed under this law. The probable loss in poultry from these animals, estimates[1] Dr. C. H. Merriam, amounted to about 5,000 fowls per year, which, if valued at 25 cents apiece, would amount to $1,875 in one and a half years. This price is fair, as most of the poultry was young. So the state was taxed $90,000 to save $1,875, which the farmers and legislators soon saw was bad economy. But the loss to the state was really greater, says Dr. Merriam, if we think of the useful owls and hawks that were killed, and of the loss of many thousand dollars' worth of grain caused by field mice, gophers, etc., which were allowed to live. Figuring on the grain eaten by the mice, and on the capacity of three or four mice per owl each day, he estimates a loss in grain of $3,500,000 in the one and a half years that the law was in force. This is an excellent object-lesson. Common hawks and owls, excepting the sharp-shinned and Cooper's hawk, and the great horned owl, are much more beneficial than harmful, and should not be killed.

The English sparrow has acquired a rather bad reputation in this land, though when first introduced it was hoped that it would be useful in destroying insects. About 1850, various eastern cities were afflicted with a scourge of cankerworms that destroyed the foliage of the shade trees in the streets and parks, and thereby injured the trees. It was thought that the English or house sparrow, being accustomed to city life, would rid our cities of these plagues. So, in 1850, several pairs of sparrows were imported and set free in Brooklyn, and a few years later a large lot were brought to the same city and other places, and the bird became established. Not

[1] Report, 1886, Ornithologist of U. S. Department of Agriculture.

only did it become established, but, finding conditions so agreeable, as do many other immigrants, it thrived and soon spread throughout the East and Middle West, and is on its onward march across the continent. Not only is it to be seen in almost every village and city, but it has even invaded the rural regions. Now, if the expectations of those who introduced the bird had been realized, it would be well. But, unfortunately, the sparrow is not as insectivorous as was hoped, and has the habit of eating grain. He is a pugnacious little bird, and will drive away other and more desirable birds, like the robins, bluebirds, swallows, wrens, etc. He pre-empts the bird houses we put up for these birds, and has been known to destroy their nests, eggs, and young. He is a nuisance generally in that he clogs up rain-spouts on the houses, or builds his rather unsightly nests in all kinds of nooks and on all kinds of protected cornices and mouldings, and soils the houses with his roosting places. Moreover, the shrill, monotonous chirping of the sparrow becomes very tiresome. All these things have caused a revulsion of feeling against the sparrow, and now there are frequent and serious proposals and even attempts to destroy him by wholesale, by snaring and poisoning and the destruction of eggs. But these attempts are hopeless now that the bird has spread. The English sparrow has come to stay, and we must pay the penalty for bringing him here by enduring his annoyances.

There is, however, this to be said in favor of the house sparrow. He frequents the busy streets that would be avoided by other birds, and he enlivens them by his presence. Then, too, he does eat insects to a certain extent, and these are chiefly the diet of the nestlings. Sparrows also eat a large

quantity of weed and grass seed. I have often seen them collecting caterpillars from infested trees, and have seen flocks of them on the lawns, eating the seeds of crab-grass and other weeds.

CHAPTER X

PROTECTION AND PRESERVATION OF BIRDS

THERE are many natural checks to the over-multiplication of birds. They have their natural enemies, such as birds of prey, weasels, minks, foxes, cats, and snakes. There are parasitic and other diseases that destroy many. The elements are especially destructive of bird life. On their migrations birds are driven out of their course by adverse winds, and falling from exhaustion are killed on the ground. They are also beaten against trees and buildings, or fall into the sea, if they happen to be attempting the passage over the water, and are drowned. Occasionally severe cold waves penetrate far south in winter, and then many of the birds perish.

Annie Trumbull Slosson describes in *Bird-Lore*, April, 1899, the freezing to death of many birds at Miami, Florida, in February, 1899. "The next morning the sun shone brightly, though the weather was still very cold—the mercury had fallen below 30 degrees during the night. But as I raised the shades of my eastern windows I saw half a dozen swallows sitting on the window-ledge in the sunshine, while the air seemed again filled with flashing wings. . . . But alas! it was but a remnant that escaped. Hundreds were found dead. Men were sent out with baskets to gather the limp little bodies from the piazzas, ledges, and copings. It was

a pitiful sight for St. Valentine's Day, when, as the old song has it, 'The birds were all choosing their mates.'"

In the spring of 1904 when the Lapland longspurs were passing through the State of Minnesota on the way to their northern summer home, they migrated in vast flocks. They encountered cold weather, winds, and even snow and sleet, and, exhausted, they came to the ground, where they were either killed by the fall or died from exposure. The ground for miles around was strewn with the dead bodies of the birds, which lay thickly in the streets and on the sidewalks and porches of the towns in the southwestern part of the state. It will take many years of breeding to make up the loss experienced by this species.

Sometimes the birds are lured northward by mild weather in early spring, and are then very numerously destroyed by subsequent cold and snow. I recall one such spring in the rolling prairie region of Minnesota. Many ground sparrows had made nests and even hatched, when a snowstorm destroyed not only the young but many of the old birds. The bluebirds also fared very badly that year.

These vicissitudes of the birds are mentioned to indicate various agencies that tend to reduce their numbers. But one of the most serious of all the enemies of birds is man. Game birds are shot by the hunter. The farmer kills the birds because he believes that they eat his crops or steal his chickens. Rarity attracts the bird collector. Professional collectors seek the skins and plumage for the millinery trade. Even the song is a source of danger. Nightingales, finches, thrushes, etc., are snared by thousands, to be sold as cage birds. Eggs are collected for the markets, from the cliffs and islands on the coast. Would-be ornithologists collect eggs and

shoot birds to make a "collection." Small boys and grown men destroy thousands of birds for "fun" with sling or gun.

FIG. 26. Hunting Grouse.

The game birds suffer most. The wild turkey and the pinnated grouse are almost exterminated. In the days of

Audubon wild pigeons were so numerous that they formed flocks that were miles in length and actually darkened the sun. Nowadays they are rare.

The unrestricted shooting of game has driven many kinds to less settled regions or almost destroyed them. Such shooting is especially destructive in the breeding season, and an element of unnecessary cruelty and wantonness is added when the young birds are left to starve because the parents are killed.

On the seacoast much harm is done the birds by the collection of eggs, often by boat-loads, from the rocky islets and cliffs. These eggs are eaten, or are used in tanning and other industries, but the birds that are robbed are discouraged and driven from their accustomed breeding places, and, of course, the multiplication of the species is curtailed.

Even our harmless or useful song birds are killed. Through ignorance or prejudice, farmers and others destroy them because they take a little grain or fruit. Hawks and owls, which are as a class very beneficial, are generally killed as chicken thieves. The small boys with air-guns, sling-shot, or other weapon do a great deal of harm in the name of pleasure or sport. Such "sport" is very reprehensible, and should be severely checked by parents, teachers, and civic authorities. In many cities laws are passed prohibiting the killing of song birds. Animals in parks are generally thoroughly protected for the benefit and pleasure of those who go there, and this principle should be extended to the wild birds everywhere.

Our schools, by sensible and sympathetic study of the birds, can do much to counteract their destruction. More correct ideas can be taught about their harmfulness and use-

fulness, their natural checks and enemies, their habits and food, and the need of close seasons in hunting. A knowledge of bird life, and a sympathetic interest in birds, should do much for the cause of their protection. I believe it would be a good thing if the principal features of the game laws of each state were read to the boys in the schools once a year, and the meaning and purpose of the laws made clear.

It is a question how much shooting of birds may be justified in the name of science. The average boy certainly should not be encouraged in making a collection of stuffed birds. There may be some boy with a marked interest in ornithology who may be permitted to shoot birds for such a purpose, but he should be advised not to destroy any more life than necessary.

Many boys have the egg-collecting fever for a short while, during which they may commit much harm. If the collecting is done with a serious purpose, to learn more of the birds, it may be encouraged, but with proper restraints. The collector should not take the whole clutch of eggs from a nest, but only one or two. When eggs are collected, as in the case of the ordinary stamp collections, merely for the collecting, and when the collectors make a practice of selling their eggs, the practice should be checked.

We have our societies for the prevention of cruelty to animals. These societies are largely composed of women. Yet many of these same women, who would have a man arrested for beating his horse inhumanly, or for leaving it unblanketed in the cold, will contentedly and with pleasure wear hats adorned with the plumage of birds, plumage that was obtained by the death of the bird to which it belonged.

Of course this is generally due to thoughtlessness. These women would shrink with horror at the thought of doing the killing themselves, or even if they realized fully that others had to do it for them.

From the tropics to the polar regions birds are shot for plumage for the millinery trade. As the feathers for hats sometimes bring $15 per ounce, it is a great temptation for men to go and hunt the birds. Beautiful paroquets, orioles, tanagers, terns, egrets, and other kinds of harmless or useful birds are killed in great numbers. If ladies must adorn themselves with borrowed plumage, let them use the feathers of game birds, which are shot for food anyway, and of the domesticated birds, among which we may now include the ostrich.

The story of the American egret and the snowy egret, which furnish the beautiful aigrettes for hats, is especially pathetic. Aigrettes are the plumes that develop on the head, wings, and back of the egrets, and are finest in the breeding season. In the southern part of the United States, where they live, they form large colonies where, in the breeding period, it is an easy matter for hunters to kill them by hundreds. The saddest feature of this slaughter is that, when their parents are shot, the young are left to starve miserably. Women should be ashamed to be in any manner connected with this cruel business. As long as they will buy and wear aigrettes, however, there will be a demand for the plumes, and hunters will be paid to furnish them.

The millinery trade demands enormous numbers of feathers whenever they are the fashion. Some plumage is imported from other countries, particularly the tropical regions, where the birds are most gorgeously colored.

A dealer in bird skins in three months killed 11,000 birds in South Carolina. He sold 30,000 a year mainly to the millinery trade. A New York milliner, who wanted 40,000 skins, hired men to shoot gulls, terns, etc., on an island off the coast of Virginia, and paid 10 cents apiece for them. During four months a Long Island village furnished 70,000 terns and land birds for the trade.

Happily, a change seems to be taking place in regard to the wearing of feathers, though how long the present decrease in their use will last is impossible to state. It may be that when feathers are next in vogue in millinery, the birds will again suffer. But at present most ladies, in this country at least, have had the cruelty of the practice of wearing plumage shown to them, and prefer not to wear it. The crusade of the last twenty years against the wearing of feathers seems to have had good results. In our schools the cause of protection for the birds has been helped. Various ornithological societies, the Audubon Societies, and the League of American Sportsmen have united in showing the enormity of the destruction of birds that has been going on, and in urging the abandonment of the fashion of wearing feathers. The periodical and daily press also have lent their aid in this good work.

As a result of all this agitation the separate states and the National Government have passed laws regulating or prohibiting the destruction of birds, the shipment, and even possession of plumage of birds other than game. The Lacey Act, passed by Congress in 1900, prohibits the importation of all foreign birds except such as are permitted by the Secretary of Agriculture. This prevents the importation of birds from the tropics or other countries,

and aids the states in stopping the traffic in birds across their borders.

While the laws are not all that is to be desired, they still go a good way toward the protection of harmless and beneficial birds. Of course there are time limits set for the hunting of game birds, and the export of game is prohibited. Massachusetts, New York, and some other states have millinery clauses in their game laws, and make the sale or possession, and even the wearing of the feathers of protected birds a misdemeanor. No doubt through the enforcement of these restrictive laws the millinery traffic in plumage will diminish greatly.

Audubon Societies

In 1886 there was started by Dr. George Bird Grinnell, editor of *Forest and Stream*, an organization for the protection of birds other than game in the State of New York, which soon had branches in almost every state in the Union. This organization was called the Audubon Society, in honor of that great naturalist and lover of the birds, John James Audubon, who studied American birds in the first half of the last century. The chief work of this society was to combat the large trade in feathers for millinery purposes, and when this trade declined, partly through the efforts of the society and partly because of a change in the fashion in hat decoration, the society died out. In 1896, however, on a revival of the feather trade, new Audubon societies were formed in different states, notably in Massachusetts. All the state societies are bound together by a national committee.

The aims of the present Audubon societies are, first, to awaken public sentiment in favor of the birds by means of

society meetings, libraries of bird literature, lectures, school-work, bird calendars, bird charts, the observance of Bird Day in the schools, outings for bird study, pins, badges, etc.; and, secondly, the establishment of protective legislation for other than game birds, and its enforcement. The protection of game is left to the various national and other sportsmen's leagues.

The magazine *Bird-Lore* ($1.00 per year) is the official organ of the Audubon societies, and it is also interesting and valuable for its descriptions of birds and bird life.

The trade in feathers has been greatly checked, as far as our native birds are concerned, by the efforts of the Audubon societies. Restrictive laws have also been passed prohibiting the importation of foreign birds, and wardens have been engaged to protect the gulls, terns, and other sea birds on the Atlantic coast from the depredations of hunters.

There will always be need for such organizations. In certain communities or regions there develops from time to time a lack of interest in the birds, or a prejudice arises against certain species, or the boys have the egg-collecting fad, or worse, wantonly shoot the birds with gun or slingshot. At such times the organization of the children and interested adults into Audubon or similiar societies would be an excellent thing. As soon as a healthy sentiment is awakened against it, the evil will be checked. Even though the organization is disbanded later, it can easily be reorganized as soon as another need for it arises.

Bird Day in the Schools

Many schools set aside a day in spring as Bird Day. Its purpose is similar to that of Arbor Day, to disseminate

knowledge about the birds, and to arouse a more general interest in their protection. The idea originated with Professor C. A. Babcock, of Oil City, Pa. In May, 1894, a day was observed there as Bird Day, and the schools of other cities soon followed this example. Now the day is a regular feature of the school calendar of several states, and in some of them its observance is even recognized by law.

Education is very properly recognized as one of the most

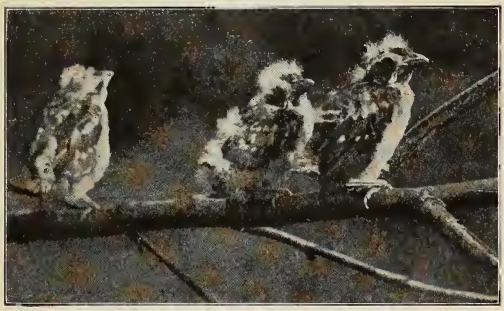


FIG. 26. Young Grosbeaks.

important factors in bird protection. Courts of law and officers are not as effective for this purpose as a strong sentiment in school children in favor of the birds. For the small boy is most destructive of the local song birds. By education proper sentiments can be instilled into the boys that will remain with them as men, and, not least in importance, the girls can be taught to see the cruelty of wearing birds' plumage and to abhor the fashion for that reason when they grow up.

Bird Day should be the culmination rather than the beginning of bird study. After the birds have been studied

intelligently and sympathetically during the early spring, let Bird Day be observed. It will then be appreciated better and be more effective.

The following are suggestions for Bird Day programmes, which can be modified according to the age of the children.

Original essays, giving descriptions of certain local birds, bird habits, bird haunts, bird food, etc. Discussions on the benefit and harm from birds. Reading of the game laws, and their explanation. Reading of the laws protecting song birds. Reading of Senator Hoar's petition of the birds to the Legislature of Massachusetts. Impersonations by the children of certain birds, the description of their habits, and the guessing of their names. Reading of literature published by the Audubon and other protective societies descriptive of the destruction of the birds and the use of plumage in the millinery trade. A discussion of the natural enemies and dangers of birds. The account of personal experiences with the birds by the children and others. Recitations of poems and readings of prose selections about the birds. An excellent feature would be an illustrated lantern-slide lecture by some one who has made a study of the birds. The room could be decorated with nests (old ones), colored pictures of the native birds, children's drawings of canaries, and parrots, etc., in cages. The reading of Longfellow's "Birds of Killingworth" is especially appropriate or the day.

In places where the birds are much persecuted it would be well to make special effort on Bird Day to interest old and young in its observance. School patrons, and other citizens, civic authorities, etc., should be invited to attend, and beneficial legislation might result in the end.

Attracting the Birds

It is possible to attract birds near our homes if we can surround them with the conditions they demand. The best way is to plant trees and shrubbery about the house. There should be clumps of trees and shrubs so as to afford shelter and concealment and places for their nests. Evergreens are much used by the birds as shelter against wind, snow, and rain, and are a favorite choice for building-sites. Fruit trees and berry bushes are sure to attract birds, not only for the fruit, but for the caterpillars and other insects that live on these plants. Wild berries and fruit seem to be preferred to cultivated ones. Choke-cherry, mountain ash, raspberry, barberry, currant, etc., and grape and woodbine afford food, some of them even to winter birds. Clumps of hemp, ragweed, sunflower, etc., attract the seed-eaters. Nuthatches, woodpeckers, chicadees, and other winter birds can be induced to stay during the summer by feeding them in the winter months. Pieces of tallow or bacon fastened to the trees in the winter will be relished by the birds.

In towns cats are the worst enemies of the birds, and should not be allowed to run at large if one wishes to attract the latter.

In the summer a very good way to attract the birds, especially if they have far to go for open water, is to set up a drinking and bathing fountain or basin. These are much appreciated by the birds. A drinking trough or basin is made by nailing a board on top of a post or by placing a shelf on the trunk of a tree. On this put any large, shallow dish, a stone crock, a large flower-pot saucer, or chopping-

bowl, filled with water. The water should be renewed daily and the dish frequently cleaned. In the hot, dry weather of summer many birds will come to drink and bathe. It is pleasant to see the birds taking their baths. I have had such a drinking and bathing basin for several summers, and consider it one of the greatest satisfactions I get from my garden. Right in the heart of the town the basin is visited by robins, bluejays, grosbeaks, catbirds, orioles, and, of course, numberless sparrows. At one time I counted as many as eighteen house sparrows at the basin at one time. The robins are especially regular visitors to it. No other bird seems to bathe as regularly as this one and to enjoy its bath so thoroughly. The basin-stand may be made more attractive by growing plants in a box around the basin, and vines at the foot of the post. Some branches nailed to the post furnish convenient perches and add to the rustic effect. Such a drinking basin should be set up on the school ground,

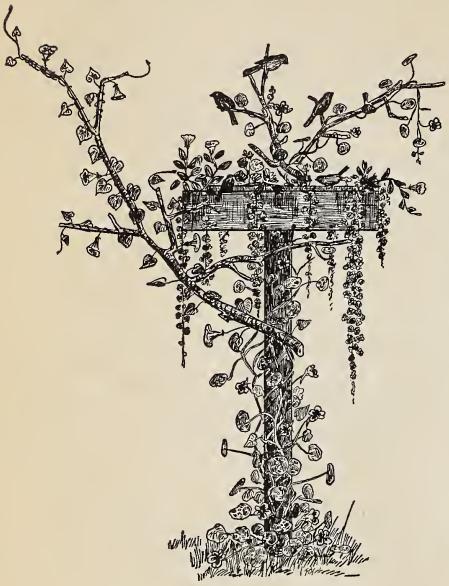


FIG. 27. Drinking Trough.

though, of course, not as many kinds of birds will visit there as in less public places.

One very pleasant memory of my boyhood is that of the bird houses near my home. I waited eagerly in the spring for the bluebird that, year after year, built in one of the houses, and for the purple martins that dwelt sociably in a multiple cot.

Suggest to the school children the building of bird houses early in spring. This is a good exercise in manual training. Birds prefer a house made of weather-beaten boards to one freshly painted in bright colors. If you paint the house at all, paint it a dull color. Almost any sort of box, about 8x8x10 inches will do. In one end cut a hole about two inches in diameter for the entrance, and fasten in front of the opening a perch or a platform for the bird to alight on. For the house wren the opening should be made in the box near the top, and it should not be more than an inch in diameter. This allows the wren to enter, but not the sparrow. Sparrows are a nuisance in many ways, but chiefly because they drive away other birds. They begin to nest earlier than most other birds, and often pre-empt the houses designed for martins and bluebirds. Keep the boxes closed till the right birds arrive. Bird houses may be fastened to the walls of buildings, on the gables of barns and sheds, or attached to trees. Some birds, like the wren and the bluebird, prefer to have the house shaded from the mid-day sun. Houses may be placed upon poles, especially for the martin. Rustic houses may be made by hollowing out a block of firewood, or by nailing bark or small saplings on the outside of a board house.

In this connection encourage boys to keep doves and

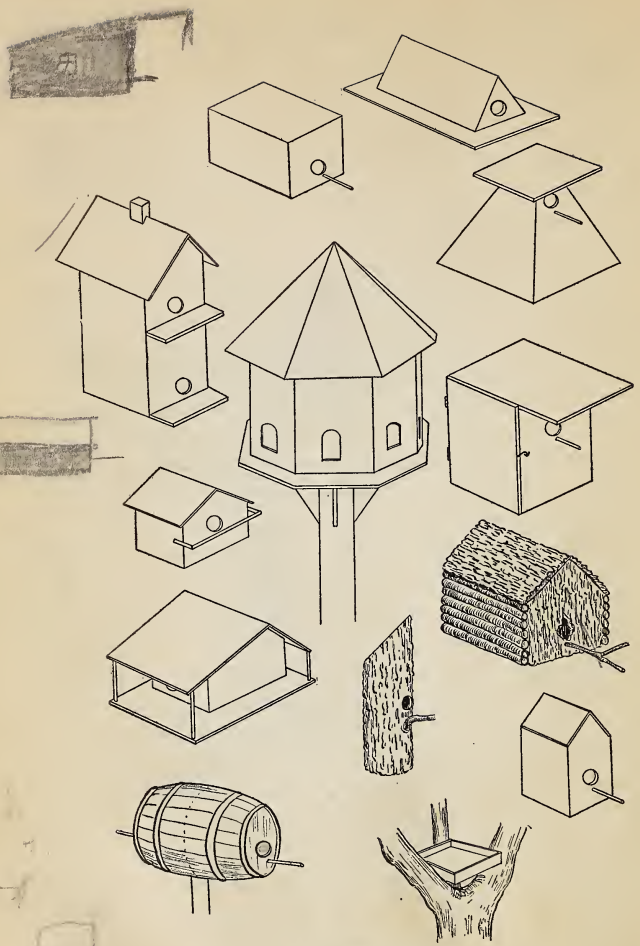
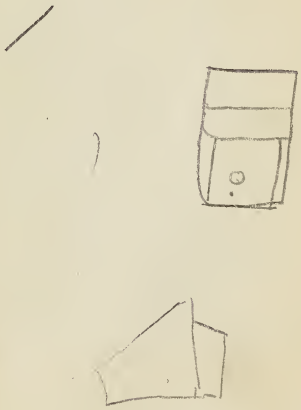


Fig. 29. Bird Houses. Robin Tray.

poultry. Have them send to the United States Department of Agriculture for Farmers' Bulletins, Nos. 41, 51, 64, 128, 177, 182, and 200, which give excellent directions for the keeping of poultry and doves. These may be had free of charge.



CHAPTER XI

FROGS, TOADS, SALAMANDERS, SNAKES, LIZARDS, TURTLES, ETC.

As unattractive as this title may seem, nevertheless the animals named should be studied in nature-study. Prejudice and repugnance once cast aside, these creatures are very interesting, and furnish some very profitable lessons.

One reason why they should be studied is to combat the superstitious dread that children and so many grown people have for them, and which creates such a dislike that it results in the killing of a vast number of these harmless animals. Of course it is proper to caution the child against the few really poisonous or dangerous reptiles that we have in this country, but it is positively wrong for parents and others to make children afraid of the harmless ones; for example, the useful toad and the pretty little garter snake. Toads do not cause warts, and garter snakes are neither vicious nor poisonous. The fear that many children have of reptiles is very great, and we do them a service if we dispel this through proper knowledge. Perhaps a little of this fear is instinctive. Many lower animals, the dog, for instance, show their dislike for reptiles; but most cases of fear in children are the result of education, or rather false teaching from parents and companions. If we teach our children that frogs, toads, and snakes are harmless, and even useful in destroying harmful pests, perhaps they will treat them more humanely. As it

is now, the average boy feels that he is doing a sort of duty in killing a snake on sight, and he delights in killing frogs and toads just for sport.

There is really no excuse for this killing, when we remember that it is generally the useful or harmless amphibians and reptiles that are killed. There are no venomous snakes in the northern half of the United States except the rattlesnakes, and these are pretty well exterminated in the more settled regions. There are no other poisonous reptiles in this region, and the amphibians are all harmless.

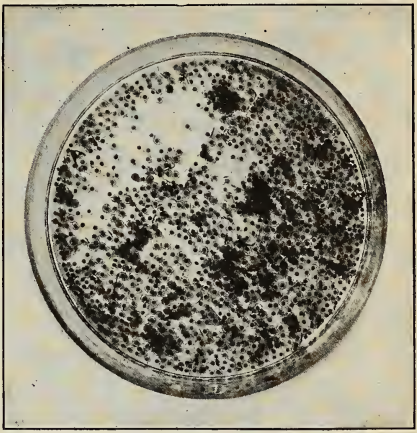


FIG. 30. A Dish of Frog's Eggs.

In the South there are the poisonous copperheads, moccasins, and the little coral snake. In the Southwest there is one poisonous lizard, the Gila monster.

Most people call salamanders lizards, and do not know what amphibians are. Amphibians, such as the frog, toad, and salamander, have a soft skin without scales. This is generally kept moist for a time by an excreted liquid. The boys will know that their frogs for fishing will die if they are not kept moist. This is necessary for the reason that

the skin is used partly as an organ of respiration. As a rule, these animals do not have claws on their toes.

But it is their development from the egg that especially differentiates amphibians from the reptiles. The eggs are generally laid in the water, or in some moist place, where

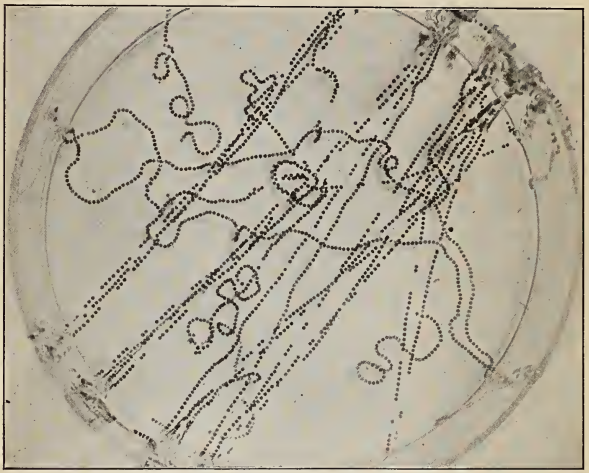


FIG. 31. Strings of Toad's Eggs.

they hatch from natural heat, not into frog-like or salamander-like forms, but into tadpoles.

Tadpoles at first have no visible gills, but very soon there develop on each side of the head or neck branching gills. Later these disappear, inside gills develop, and gill slits are left in the neck as in fishes. In fact, the tadpole stage corresponds very closely in its structure and physiology to the fish. During this time the tadpole lives an aquatic life

and breathes the air in the water with its gills. At this time the food is mainly vegetable, consisting of minute algal vegetation.

Gradually, as the tadpole grows, lungs develop. Also about this time limbs develop. Finally the tail disappears, not by dropping off, but by gradual absorption and transfer of

Fig. 32. Development of a Tadpole.

its substance to other parts. This loss of the tail applies only to frogs and toads. Salamanders, mud-puppies, etc., retain them.

After the limbs and lungs have developed, most amphibians leave the water and breathe the air, their gills usually first disappearing. Thus frogs, toads, and salamanders become more or less terrestrial. This does not mean that they shun the water thereafter. In fact, frogs continue to live what we generally call an amphibious life. They like moist places, wet meadows, damp woods, and many species spend a good share of their lives sitting half-submerged in the water of swamps and lakes. Salamanders are found in damp cellars or in damp

woods and other moist places. Toads appear the most accustomed to dryness, often being found far from water, in gardens, on the lawns, and in dry woods. Tree-toads, as their name implies, live among the foliage of trees. But the necturus, or mud-puppy, found in many of our streams, is an amphibian with very rudimentary lungs, and in adult life still retains its bushy external gills, and does not leave the water.

The Frog may be taken as the type of the amphibians. In the spring, soon after the first piping and croaking resound in the marshes, visit these breeding places and look for eggs. They will be found in the form of large jelly-like clumps or masses attached to submerged sticks and plants. Bring some home and, placing them in a dish of water, observe the development of the tadpoles that soon hatch out. Do not place too many eggs in one aquarium. It is better to put only a few in one vessel. A fruit-jar or similar vessel will do very well for the hatching, but a shallow dish, slightly tilted at one end, or a shelving vessel so as to give a variation in the depth of the water, will be better for the development of the tadpoles. Place green algæ and other water plants in the water for the tadpoles to feed upon. They will also eat cooked corn-meal. They will not grow unless fed. Frogs are not easy to raise to maturity in an aquarium, but the tadpoles of toads, which in general resemble those of the frog, are more easily raised. Tadpoles are great feeders, and will very soon clean off the algal scum from the sides of an aquarium. The algæ should be replenished from time to time. If only a few tadpoles are in an aquarium there is less care in feeding. The children will be greatly interested in the development of the tadpoles. Watch the formation of outside gill branches, the replace-

ment of these by the internal gills and gill slits, the development of the legs and the gradual loss of the tail.

If you do not have good luck with the raising of the tadpoles in the aquarium, have the boys catch some that have been living in the pools and swamps and have developed naturally. Make observations upon these. If there is a small natural pool or tank near the school, place eggs there and good results may be had.

Frogs are interesting and harmless creatures. Their cheerful piping or croaking in the early spring is a pleasant sign of the season, though a large colony of frogs near dwellings may become a considerable nuisance on account of their loud concerts. Different species of frogs have different notes or songs. Some of the smaller ones have shrill cricket-like chirps, while the great bullfrog has a deep base "jug-o-rum" call. At times at night it seems as if all the frogs in a pond were "singing" in concert, all keeping time together beautifully.

Frogs in the tadpole stage are chiefly vegetarian in their diet, but after leaving the water they are almost exclusively carnivorous or insectivorous. They then eat insects of all sorts, worms, spiders, etc. The larger forms will even eat lizards, snakes, and small mammals.

Frogs and toads have peculiar tongues. They are fastened in front and folded back in the mouth, but may be shot out quickly at an insect or worm, which adheres to the sticky surface and is thus drawn in. Feed a toad some angleworms, meal worms, or insects, and the action of the tongue is well seen.

Watch a frog breathing. He seems to be swallowing all the time. He is swallowing air which he forces down into his lungs. How do we breathe? When we inhale we increase

the chest cavity by raising the ribs with the muscles attached to them. The atmospheric pressure then forces the air into the lungs, which thus fill the expanding chest cavity. Exhaling requires no effort. We simply relax the muscles and let the ribs descend, their weight forcing out the air. But frogs have no ribs. There are simply stumps or rudimentary ribs on each side of the backbone. So a frog cannot breathe as we do, but has to force the air in by swallowing. As before mentioned, frogs breathe somewhat through their skin. The croaking is made by inflating the throat and cheeks. Observe this in a frog or a toad.

The feet of the frog are webbed so as to enable him to swim well. The toes of the hind feet are much elongated, and with the web make an excellent paddle. Place a frog in the water and see what an expert swimmer and diver he is. The hind limbs are long and strong, and are well adapted for leaping. Notice how the frog at rest squats with his legs all ready for the jump. Try to make him jump. Measure some of the longest jumps and compare this distance with the frog's length. Can a boy jump as far in proportion?

Hold a frog under water a short time. Note that he pulls a thin, transparent film over the eyes. What is its use? It is the lower eyelid.

Just back of the eye is a circular area with a smooth, flat surface. This is the ear, and the membrane is the ear-drum. Frogs have a keen sense of hearing. Any one who has approached a swamp where the frogs were holding a concert will know how quickly they stop at the snapping of a twig, the rustling of the grass under foot, or any other sound made on coming toward the swamp. The fact that frogs have "a song" implies an ear to hear it.

The colors of the frog are admirably adapted to conceal it. The species that sit most of the time along the edges of pools and swamps are so colored and mottled as to resemble closely the water plants among which they live and try to conceal themselves. Those that are more terrestrial are similarly protectively colored. This is especially well shown in the small tree frogs, which are able to change their color within limits, according to the surface upon which they sit. When we think of the snakes, turtles, cranes, herons, bitterns, ducks, crows, hawks, owls, and different mammals that are always on the lookout for frogs, we can see the wisdom of such protective coloring.

Another peculiarity, shared with other amphibians and reptiles and many other animals, is the habit of sleeping through the winter. Only the frog sleeps in the mud at the bottom of ponds and swamps, under the ice, where he stays till spring releases him. At this time the skin is the organ of respiration.

It may be asked of what use are frogs. They play their part in nature, and on the whole a useful one. They destroy a vast number of insects, and they themselves serve as food for other animals. They are good for bait, and frogs' legs are used as food in large quantities by man.

There are a number of species of frogs. The following are some of the most commonly seen.

The Bullfrog is the largest, and may be recognized by its deep base voice. It is of greenish color above, mottled with irregular blotches of brown or black, and underneath it is white. The web extends to the tip of the fourth toe. It is found in swampy places.

The Leopard Frog is the most common. It has a greenish

back dotted over with dark spots not arranged in straight rows, and white or yellowish underneath. There are several dark bands across the thighs.

The Brown or Pickerel Frog is brownish on the back with squarish dark spots in rows.

The Common Tree Frog is green, brown, or gray in color, with irregular darker streaks down the back. It lives on trees, shrubs, and vines. Owing to its mimicry of the background it is hard to find. Its chirping is often heard at night.

The Swamp Tree Frog is a small frog, grayish in color, with three dark stripes running along the back. It is found in marshes.

These tree frogs are charming little creatures and make interesting school-room pets. Place them in a moist cage and provide them with a rock or wooden perch, such as the branch of a tree. The changes of color in the common tree frog can be nicely seen by substituting perches of different color, green, gray, and brown. Feed the animals with worms, spiders, and insects. Observe the small disk-like pads at the ends of the toes and fingers. Observe the frog clinging to the vertical wall of the cage, and notice how the little pads are pressed against the surface. They act as suckers and enable the frog to climb. The soft, moist underside also helps the animal to stick on.

The Common Toad is another interesting animal, and should be compared with the frog as to structure and habits. Toads are found in gardens and in the woods. They are very unlike their relatives, the frogs, in that they live in dry places. They keep their skin moist, however, by secretion. The skin is wrinkled and warty-looking, though there are no

true warts, and the idea that handling a toad causes warts is wrong. Toads do exude an acrid fluid from the skin which may irritate cuts or scratches on the hands, but it does not cause warts. The excretion is probably a protective device. The skin of the toad is dull colored, so that when it sits on the ground or lies half buried in the ground it resembles the earth so closely as to be difficult to see. The movements of the toad are slow and cumbrous as compared with the nimble frog's. The toes are webbed, which would indicate that the toad, in spite of its land habits, is a swimmer.

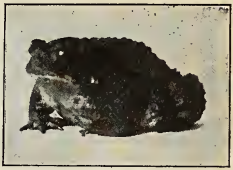


Fig. 33. The Toad.
(A very useful animal.)

In the early spring, after coming out of hibernation, the toads assemble for a period in swampy places, where their long, plaintive pipings (from the males only) may be heard. Visit such a place, and the toads will be seen spawning. The females are larger than the males, being full of eggs. The females lay the eggs and the males fertilize them. The eggs are laid in long ropes or strings on the bottom of shallow water, and are attached to water plants. Collect some of these eggs and place a few in a dish or vessel of water together with some green aquatic plants. When first laid they are about as large as a pin-head, but the jelly-like matrix in which they are imbedded soon absorbs water and swells. The eggs of toads are blacker than those of frogs, as are also the tadpoles or polliwogs.

The treatment of the tadpoles of the toad should be the same as for frog tadpoles. Their development, which is the same as that of frog tadpoles, only more rapid (about two months), should be observed by the children. As the

tail gradually disappears, the young toads become more and more terrestrial, crawling up for a time out of the water. A visit to the ponds and marshes about the beginning of July will perhaps show many young toads leaving the water for the land. They have not yet become wrinkled and warty.

After the laying season the old toads return to the land. Their habits are chiefly nocturnal. They like to burrow into

FIG. 34. Protective Coloration of the Toad.

the soft soil during the day to escape the heat of the sun, or else lie concealed under a large-leaved plant, a board, or other protection. Toward evening, however, they leave their hiding places and hop about the lawns and gardens in search of food. This consists of worms, caterpillars, beetles, flies, and other insects, slugs, sowbugs, etc. These they catch, like the frogs, with their long extensible tongues. Catch a toad and bring it to school. It soon becomes tame if kindly treated. Set it on the floor or desk, and place worms,

insects, bits of fresh meat, etc., before it. After observing it for a while, and slowly approaching the food, the toad all at once, quick as a wink, has licked up the morsel. Children will be much interested and amused at seeing it eat. Toads may be tamed in the garden so as to come at a call or whistle to be fed.

So useful are toads that gardeners like to have them in their gardens. Next to the robins I consider them my best helpers in destroying cutworms, beetles, and other injurious insects. Toads may be found elsewhere and brought home and placed in the garden, where they will generally remain and do good work.

Teach the children the harmlessness and great usefulness of toads, and discourage the erroneous belief in their wart-producing power. By all means discourage the cruel and senseless habit that many boys have of killing these little creatures.

Toads hibernate. They burrow their way backward into the soft earth till they are deep enough not to be affected by the alternate freezing and thawing of fall and early spring, and here sleep away the winter in a kind of torpor. In the warm spring, however, they dig their way out. This act of going into winter quarters may be observed, if we place a toad in a box of loose earth in the latter part of the fall. If the box is placed in a cool spot the toad will probably begin to burrow sooner.

Is the toad ugly? Of what use is his ugliness to him? He certainly has a very beautiful eye.

Salamanders are tailed amphibians and are often miscalled "lizards." They develop much like frogs and toads, except that they do not lose their tails, and their food is the

same. They are found in damp or wet places, under stumps and logs, and they lay their eggs in jelly-like masses in the water. There are several rather common forms.

The Spotted Salamander is seen most frequently. It is a soft-skinned, sluggish creature, black above and spotted with yellow blotches.

In the Eastern States there are other common salamanders, the Newts, or Efts, and the Tritons. The first, if found in the water, is green in color, spotted red on the back, and it has a flat tail. A variety of this species (Red Eft) lives out of the water and is red on the back.

The Red Triton is about twice as long as the newts, six inches, and is red on the back, spotted with brown. It lives in pools and streams.

Another salamander-like creature occasionally caught in our rivers is the Mud-puppy. This looks like a large, heavy salamander, and attains a length of two feet. It has external branching gills, however, and does not leave the water. Its color is brown.

These salamanders are not venomous and may be handled with impunity. They make interesting animals for the aquarium or moist cage.

Reptiles differ from amphibians in that they have a scaly, or plated, skin, and clawed feet (if any), and that their eggs hatch directly into young resembling the old, which breathe by means of lungs from the time of hatching, without passing through the tadpole stage. The following is a brief description of some of the different orders.

Our Lizards are active little creatures that like to bask in the sun. They are slender, long-tailed, and have four legs. Their bodies are covered with scales. They feed upon in-

sects, worms, and other small creatures. The most common kinds in the northern part of the United States are the Swift, about seven inches in length, and bluish or bronzed and black in color; and the Bluetailed Skink, also called "Scorpion," about ten inches long, and olive backed, with five yellow streaks, and blue tail. In the Southwest there is a curious rough-scaled lizard, called the Horned Toad, that is very common. In the Southern States there is found a pretty little lizard called the "chameleon" (not properly a chameleon), which one frequently sees exposed for sale in the North as a pet. This little lizard has the power of assuming different colors—green, gray, yellowish, bronze, and black. It makes an interesting pet for the school-room, but should be properly cared for and not left to starve and thirst to death.

Snakes are interesting from several standpoints, and should be studied. They have a long slender body with usually a tapering tail and no external legs.

There are rudiments of the hind legs in some snakes, which seems to indicate that at one time the ancestors of our snakes had legs, but by disuse they became rudimentary or were entirely lost. How do snakes move if they have no legs? Observe a snake "run." It wriggles with a sinuous motion, and by the help of its rough, scaly skin and by a slight motion of its numerous ribs it can move very fast. Chase it into the water and see how gracefully it can swim. Catch a common garter snake, so common everywhere east of the Rocky Mountains. This is found in meadows and along lakes and streams. It is about two feet in length, and is of a general green or olive color, striped lengthwise with yellowish and black stripes. Keep it in a cage in the school-room, and give it a basin of water and some earth on the floor

of its cage. Give it some large insects and frogs to eat. It is interesting to see it eat frogs, which are generally seized and eaten alive. The snake does not chew its food, but swallows it whole. By a curious dislocation of the jaws at the back, allowing the mouth to distend widely, it can swallow a frog of larger diameter than itself. The snake secretes a large amount of saliva, which flows over the frog and makes it more easily swallowed. The two halves of the lower jaw are hinged together in front and are separately movable backwards. This arrangement is very useful in swallowing small animals.

Perhaps another interesting habit of the snake will be observed,—the shedding of the skin. Our skin is constantly coming off in minute scales or shreds, rubbed off by the clothing and in the bath, but it is being renewed continually from beneath. So it is with snakes, except that periodically they shed their skin whole. Sometimes a very perfect sheath is left in the shedding.

Snakes' eyes are always staring, for they cannot close or move them. They are covered with a transparent skin and have no lids.

Snakes live in burrows, crevices, and under litter, or in the holes left in the earth by decayed tree roots.

Non-venomous snakes, on the whole, are useful creatures, and destroy insects, frogs, and small mammals, such as mice, moles, shrews, rats, etc. On the other hand, they do more or less harm in killing the useful toad, and in destroying the eggs and young of birds.

There are many common species of snakes in this country. As stated above, the only poisonous snakes are the rattlesnake, copperhead, moccasin, and the little coral snake.

The latter three are found only in the South. Rattlesnakes are found in almost all parts of the United States, but have been nearly exterminated in the more settled regions. Before striking with their poisonous fangs, they give a warning by means of the "rattle" at the end of the tail. This consists of a number of horny, thin, joint-like structures. These are the remnants of previous coats of skin which did not fall off with the shedding of the rest. It used to be said that each section in the rattle indicated one year in the snake's life. This is, however, not the case, as it is now known that the snake may shed its skin more than once a year.

Do not forget the Turtles. Every child is interested in them. Keep some at the school. The smaller ones may be placed in the aquarium, but a float or raft should be provided for them. Larger ones may be kept in a terrarium. Observe the feeding and other habits of these specimens. Note how they swim. Have they any teeth? Note how well the softer parts of the body are protected. The shell of the hard-shell turtles is made of a modified bony skin, grown together with the backbone, ribs, and breastbone. Are the colors of the shell protective? Hold a turtle under water and note the transparent film, the nictitating membrane, that is drawn over the eyes. In the fall a turtle in a cage with an earthen floor will be seen to be anxious about something, and trying to burrow into the ground. It is getting ready for the hibernation. If a deep lot of earth is put into the box the turtle will probably completely bury itself, particularly if the box is left in a cool place.

The soft-shelled, snapping, mud, and box turtles are the commonest in the Northern States. Let the children know about the large sea-turtles, such as the loggerhead, hawks-

bill, and the green turtle, their mode of life, capture, and uses.

The study of American reptiles would not be complete without a brief reference to the Alligator of the South. Somewhat lizard-like in form, it is nevertheless not a lizard. The habits of the reptile are interesting. Besides pictures, satchels, pocketbooks, and other articles made of alligator skin may be used for illustrations.

Like the amphibians, the reptiles hibernate during the winter in some protected place.

CHAPTER XII

FISHES—AQUARIA

In the spring, when the ice goes out of the lakes and streams, the small boy begins to think of going a-fishing. This natural interest should be utilized by giving a series of lessons on fishes. The best illustration, of course, is the live fish. There are excellent glass aquaria to be had, both globe-shaped and square, but almost any kind of vessel will do, as a wooden pail, a stone crock, a porcelain dish, a fruit jar, or a candy jar, etc. Common battery jars are excellent and may be had in various sizes. A very good aquarium may be made by a tinsmith out of angle iron soldered together for a frame, with sides and bottom of strong glass cemented into it with a water cement. Such an aquarium is a useful adjunct of the school, and adds a decorative effect to the room if properly stocked. Medium sized aquaria are best, as a large one cannot be readily or safely moved, and by using smaller vessels the animals may be kept separated. A good size for a built-up aquarium is 12x18x8 inches. There should also be aquaria of various smaller sizes, some tall and narrow, others wide and shallow, in order to suit different kinds of plant and animal life, according as they live in deep or shallow water. Insect aquaria and those for frogs, etc., should have a wire cover to prevent the animals from escaping.

Stocking an aquarium is a work the children delight in.

Take the pupils out to the pond, brook, lake, or river, and collect the things to be put into the aquaria. This should be more than a mere collecting trip. Have the children note as far as possible the conditions under which the creatures live, perhaps the food needed, the depth of the water in which they live, etc. This will teach them something of the habits of the creatures, which should be utilized in fitting up the aquarium. Gather some of the plants among which the animals live, perhaps some of the dead leaves and twigs at

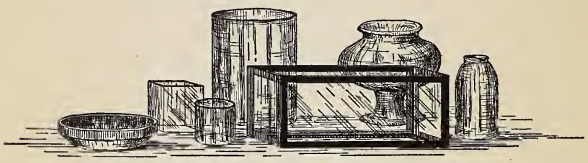


Fig. 35. Aquaria.

the bottom of the water, as these will furnish food or natural shelter for the animals.

In case of most aquatic insects a mud or ooze bottom seems best for their aquarium. The water from the pond whence they came also is often better than well or city water. For fishes and clams the bottom may be of clean sand. Pretty stones and pieces of coral and seashells placed in the aquarium will make it more attractive.

The best way to keep the water fresh and supplied with oxygen is to place in it green aquatic plants. These give off oxygen in the sunlight. This is often seen in a jar with a mass of green algæ in the water when the sun is shining on it. There are small bubbles of oxygen upon the mass. Small aquaria, with not too many animals, may be kept for months

in this way, only needing the addition of water now and then to make up the loss from evaporation.

Water milfoil, eelgrass, elodea, and filamentous green algæ are very good plants for aerating the aquarium water. Other plants may be added for beauty. The little floating duckweed is an interesting plant to have in an aquarium. Another interesting and curious plant is the water hyacinth, which may be obtained from greenhouses. With its thickened leaf-stalks, which contain air, it floats on the surface of the water.

Plant small varieties of bullrushes, water buttercups, arrow-head, small swamp sedges, marsh marigold, and other water or marsh plants, in the sand at the bottom of the aquarium, or at the edge of the water in a terrarium. This is simply a cage, with earth floor, for land animals. If a basin of water is set in this soil, both land and water conditions will be afforded. Frogs, toads, salamanders, turtles, snakes, and other animals prefer this kind of cage. It should be ornamented and made more natural by planting land and water plants as suggested.

Another suggestion for the aquarium is that an island be built of stones or earth for the benefit of turtles, frogs, and other animals that like to crawl out of the water. Plants may be placed on it also.

As an aquarium should not be too much in direct sunlight, any other window except a south window is suitable.

If an aquarium becomes coated with an incrustation, this should be removed by scrubbing.

In case it becomes necessary to change the water of an aquarium on account of stagnation, it should be done by avoiding too great change of temperature. The water probably has the temperature of the room, and the fishes

(goldfishes especially) and other animals are chilled and often killed in consequence of pouring on them water taken directly from the pump or the city mains at a much lower temperature. Let the new water stand a few hours in the room before making the change, or add warm water to it till to the hand the two waters are about the same temperature. A siphon is useful sometimes in drawing off the water, so as not to disturb the bottom and to prevent the animals from going out.

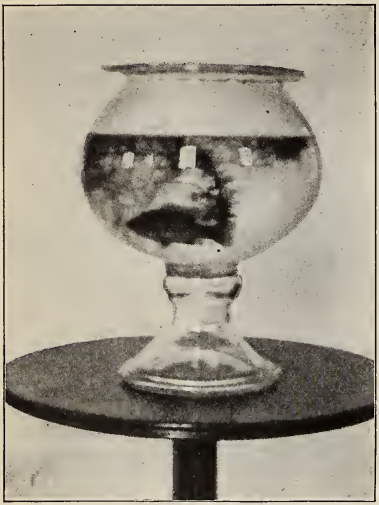


Fig. 36. Aquarium with Sunfish.

The following animals are good for stocking aquaria: Goldfishes (very hardy), small bullheads, young dogfish, carp, perch, small sunfish, minnows and darters, sticklebacks, salamanders, turtles, frogs, tadpoles, crayfish, clams, snails, leeches, dragonfly larvæ, electric-light bugs, water-beetles, water-boatmen, water-striders, water-spiders, mosquito wrigglers, and other aquatic insects.

One thing must be kept in mind, however, and that is that the carnivorous creatures are apt to eat the other smaller

animals. So keep the water-scorpions and electric-light bugs, dragonfly larvæ, perch, bass, turtles, and frogs by themselves, or with those too big for them to eat, unless you wish to add the smaller animals as food for them.

Goldfish may be fed on bread and cracker crumbs, or on the "fish food," which can be bought. Other fish and tadpoles will also eat these things. Carnivorous fish will have to be fed on insects, worms, and bits of meat. A piece of beef that has the fat boiled out, dried, and crushed into minute bits is an excellent fish food. I keep a large food-jar containing algæ and other water plants and various kinds of animalcula. Occasionally I put some of these plants with the animalcula that cling to them into the aquaria as food. In feeding aquarium animals be careful not to give them more than they will eat, else the decaying food left over will make the water sour and stagnant.

The fish should be studied as a type of animal life, with special reference to its structure, breathing, swimming, spawning, and other habits.

Let the children observe the fish in the aquarium. Note the flattened and tapering shape of the body. Is this shape of any special use? Why have most fishes this shape? How does the fish swim? It will be seen that the fish propels itself with its tail, using it as a sculling oar, and that the fins are not so much used for swimming as for balancing and directing the course. With rubber bands slipped over the back and side fins, try Professor Needham's experiment to see how a fish behaves without the use of these, and to discover their proper functions. Note the sharp spines on the fins (if the fish is a spiny-finned one). Ask the children

about the use of these. Any boy who has been fishing can tell of his experience with them.

Most fish are covered with scales that overlap each other and make a protective armor. Examine some separate scales from different kinds of fish. The outside of the body is covered with a slimy substance which protects the body and also enables the fish to elude the grasp of its enemies. The scales are often beautifully colored. Our common "pumpkin seed" sunfish displays a wonderful wealth of color and beautiful iridescence. Most fishes, however, are inconspicuously colored for protection. Brown and olive colors are common on the backs of many fishes. This renders them inconspicuous against the darker depths of the water or the bottom. Underneath, however, fishes are generally lighter colored, often nearly white. This makes them less easily seen against the bright upper surface of the water. Some strange fish of the ocean have curious warty and spiny surfaces and long streamers, so that they more effectively resemble water vegetation.

The eyes of fishes are lidless, and are usually large and staring. Their mouths differ much in shape and in position, and those of predaceous kinds are large and well supplied with teeth. Bottom feeders have their mouths more on the under side of the head.

Observe the fish in the aquarium. See how it seems to be swallowing all the time. It does take in water, but not to drink, for it forces it out through the openings at the sides just back of the head. These openings lead to the gill pouches and are closed by the cartilaginous gill covers. Take a dead fish and examine the gills. A large fish shows them better. Turn back or cut off the gill cover, and the red

gills will be seen lying in several layers in the cavity. The gills are composed of small red filaments attached to cartilaginous or bony arches. Between these arches are slits that communicate with the back part of the mouth, through which the water is forced. As the water passes over the gills, the fine blood-vessels lying in the surface of the gill filaments absorb the free oxygen in it. This is the way the fish breathes.

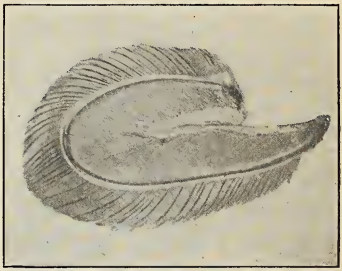


Fig. 37. The Gill of a Fish.

Dissect the fish and find the air-bladder, a long, white sac in the body cavity next to the backbone. This organ is found in most fishes and has an important function. In fish like the sunfish, bass, and pickerel, it serves as a floating device. The body of the fish is slightly heavier than the water and naturally sinks. By expanding this bladder the fish can rise, and vice versa. The same principle is applied in our submarine boats. Watch a fish in the aquarium as it rises and sinks without moving any fins. It is done by means of the air-bladder. In the dogfish and other fishes, generally of low degree, the air-bladder serves partly as an organ of respiration. It is more or less cellular and lung-like, and is connected with the mouth so that the fish may come to the surface and inhale air.

Fishes, like amphibians and reptiles, are cold-blooded animals. That is, their blood is not, as in the birds and mammals, at a higher temperature than the medium around them.

Watch the fish in the aquarium. Place some food in the water and observe them feeding. Watch the predaceous kinds catch water insects, etc. Most fishes are carnivorous, and even cannibalistic. Among them the general rule is that the bigger swallows the smaller. Aquatic insects, worms, crayfish, etc., and the minute animalcula that swarm in the water, are also food of the carnivorous fish. Some are vegetarian and feed on aquatic plants.

In cleaning fish in the spring or early part of the summer one often finds masses of roe. This roe is the unlaid eggs of the fish. Fish lay their eggs or spawn generally in the spring, soon after the ice is out of the lakes and ponds. At this time they often make long journeys or migrations to a suitable place for the spawning. They go up the rivers and streams to the headwaters, and there the female deposits her eggs. Some fish dig in the sand at the bottom of the water a shallow hollow in which the eggs are placed. Sometimes they are covered with a little sand, sometimes they are loosely laid in the water. The little stickleback makes a pretty little nest in which the female lays her eggs. Some fish take care of the eggs until they are hatched, and then for a time protect the young. But many kinds pay no further attention to the eggs after they are hatched. The young, or "fry," as they are called, and the eggs as well, are much attacked by fishes and other animals. In this connection read to the children The Story of the Salmon, in "Science Sketches," by David Starr Jordan, a very delightful and sympathetic study of the life of a fish. Show the boys that it is wrong to catch or spear fish before the spawning season is passed.

Bring out the economic aspect of the subject. This would be well done in connection with geography. The fishing

industries of the salt and inland waters, the principal food fishes, such as salmon, mackerel, cod, and herring should be studied. Refer also to the artificial rearing of fish at the state and national hatcheries. Briefly take up methods employed, and also the stocking of the lakes and other waters.

A few strange fish, such as the eel, shark, ray, flying-fish, seahorse, torpedo, and others, would be interesting illustrations of curious adaptations to special modes of life.

The following fresh-water fish are common and should be referred to in this study of fishes: There are the sunfish, the gamy little fish for the youthful angler, so common in our ponds, lakes, and rivers. Some of them are beauties, as, for example, the "pumpkin seed." Another fish, in similar places and affording similar sport, is the common perch. For the more mature sportsman the black bass are more worthy to test their skill at angling. These also abound in our lakes and streams. Related to the sunfishes and bass are the speckled croppies of the lakes. In another class belong the ferocious and large-mouthed pike, pickerel, and muskalonge of the lakes and rivers. These are well provided with teeth. They are very predaceous and attack any moving object in the water, and are therefore usually caught with the trolling hook. They are very destructive of other fish, and make gamy catches. Another famous order of fishes is that of the salmon and trout. On account of their vigorous fighting qualities salmon are considered excellent game, and trout catching is a test of nimbleness and skill with the fly. Both kinds are among the best food fish, as the flesh is excellent and the bones are not troublesome. Another order includes the suckers and minnows. Suckers generally have small tube-like mouths adapted for sucking

in food. The red-horse and the buffalo of our rivers, and the common sucker of the lakes are easy sport, and though not very good for food, are considerably caught for this purpose. Most people think that minnow means a young fish of any kind. That is not the case. Minnows are generally small, it is true, but they may be old. There are some minnows several feet in length. There are other small fish, full-grown, however, that are not minnows, as, for example, the little darters of the streams. Minnows are lively little fish, preyed upon by larger ones, and much used for bait by fishermen. Allied to the suckers is the vegetarian German carp, introduced from Europe into our muddy ponds and lakes, and now so numerous as to be almost a pest. This is a fairly good food fish. The goldfish is a species of carp originally from China. A very interesting little fish, especially for the aquarium, is the stickleback found in streams. The male makes nests for the female to deposit her eggs in. Every boy will know the common bullhead of the lakes and rivers. This is a sluggish, scaleless, slimy fish of rather nocturnal habits, and will therefore bite well after dark. It has a number of flexible feelers, or barbs, around its mouth, with which to explore its way and perhaps find its food. These feelers do not sting. Catfish and bullheads do sting or prick with the spines on their back and pectoral fins. The latter fins can be firmly locked so as to stand out straight from the body, and so the fish is disagreeable to handle. Other interesting fish found in fresh waters and worthy of study are the dog-fish, the garpikes, the sturgeons, and eels.

CHAPTER XIII

TYPICAL INSECTS

THE abundance of insects, their variety of form, beautiful colors, ingenious ways, remarkable adaptations to their mode of life, and wonderful transformations make them excellent material for nature-study. They are easily found, collected, and kept alive in cages. There is no excuse for not illustrating these lessons with abundant specimens. Outdoor observations can easily be made by the pupils individually, and field lessons with the whole class can be successfully conducted.

Children are over-cautioned against insects, so that they finally come to have a dread for them generally. This spoils much of the pleasure they might otherwise enjoy at the sight of insects and their many interesting devices. It would be a kindness to children to teach them that this fear is unnecessary. Much nonsense has been told and written about being bitten and stung by insects with terrible results. In our country, flies, mosquitoes, fleas, lice, bedbugs, ticks, gnats, bees, and hornets are the most annoying or dangerous insects. As for spiders, though not true insects, they may be mentioned in this connection. They are, as a class, harmless, only the larger running spiders and the tarantula causing painful, though not fatal, poisoning.

The great economic importance of insects, their rapid

rate of mulitiplication, and their vast power for harm and for good, should be studied in nature-study. The children should learn to distinguish the most common beneficial and harmful insects, note their habits, and learn the methods of fighting them if injurious.

Teacher and pupils should go out and collect insects for study in the school-room, and should observe their habits out-doors. Insects may be found in various places according to their food and life habits. Flower-loving insects are found in the garden, in the clover field, on the wayside flowers, and in the meadows. Flowers attract the nectar-sipping insects, such as butterflies, moths, bees, and bumble-bees. The vegetable garden will show grubs, cutworms, beetles, and bugs that feed upon the leaves or other parts of the planted crops. In the orchard we find leaf-eating caterpillars, bark-borers, plant lice, scale insects, bugs, fruit-destroying insects; and in the flowering time hosts of bees and other nectar-loving insects. Many insects, such as ground beetles, ants, cockroaches, crickets, etc., may be found under stones. logs, boards, and under the bark of decaying stumps and logs. Locusts, grasshoppers, and crickets swarm in grassy meadows and pastures.

A walk along the country road will show us swallow-tailed butterflies, milkweed, cabbage, roadside, red admiral, fritillary, mourning-cloak, and other butterflies flitting over the wayside flowers; moths of various kinds will flutter up from the grass as we disturb them, or, toward dusk, we may find them probing the deep-cupped flowers with their long probosces. Locusts and crickets are chirping in the grass or adjoining fields. Here we see the orb spider spinning its beautiful web in the fence corner, and running spiders in

search of their prey. The bees are busily gathering both nectar and pollen, and are dusty as millers with the golden pollen grains which they brush off against other flowers, thereby effecting a very essential process, that of pollination, which is necessary for seed formation. Bumble-bees are drowsily humming past or are half-buried in the depths of some flower's corolla. Here, perhaps, in a hole in the bluff along the roadside, or in a tree, we find the paper nest of the yellow jacket or hornet, which we had better let alone. In the grass and along the dusty road, we see the active and nimble tiger-beetles and other predaceous beetles, running about looking for some smaller insect which they may devour. In the footpaths along the road we see many little ant-hills, and it would pay us to pause and observe the little workers. In the grass we may find a large mound made by the larger ants, and if we open this we may see the eggs and cocoons carried hastily away by the frightened workers. In the tall elm or cottonwood trees along the road, we hear the cicada, sounding like a miniature alarm clock running down. We are lucky if we find the insect.

A visit to the pond will show us various aquatic insects. Flying over or about the pond are the gauzy-winged dragonflies, mayflies, damselflies, and stoneflies, and myriads of mosquitoes. Their larval stages will be found by dredging with a net on the muddy bottom of the pond. By lifting up submerged sticks, leaves, and stones we find water-tigers, caddisworms, water-beetles, etc. By dragging the dip-net along the bottom of the pond, along water-plants and over submerged sticks and stones, turning out the contents and examining the mud, we shall find the large and the small electric-light bugs, the predaceous water-beetle, the water-

scorpion, water-boatmen, back swimmers, dragonfly larvæ, etc. The black, shining whirligig-beetles spin about like beads upon the water, and running dry-shod over the surface are the water-striders and some spiders. All these pond insects may be kept in aquaria.

In the forest we shall find leaf-eating caterpillars and their moths. Perhaps we shall be fortunate enough to find the beautiful cecropia and the luna moths. We shall find inter-

FIG. 38. A Likely Place for Dragonfly Larvæ, Water-Scorpions, Electric-Light Bugs, Crayfish, Frog's Eggs, etc. Muskrat House at End of Pond.

esting homes of insects, such as rolled-up leaves, wart-galls on the leaves, willow cones, oak galls, etc. Decaying stumps and logs are regular hotels for such insects as ants, roaches, crickets, and beetles, also spiders, centipedes, millipedes, sow-bugs, etc. We may also find the interesting measuring caterpillars, and the remarkable walking-sticks.

Nocturnal insects may be found flitting about at dusk, such as the humming-bird moths and other moths; or they may be seen around the street lamps in swarms. By examining the ground beneath a street lamp we shall find

various beetles, moths, and other insects. At certain seasons there are great swarms of beetles flying at night, often filling the globes of the lanterns with quartfuls of insects. In the summer, also, the large water-bug, called the electric-light bug, comes out of its native swamps and flies around the street lights, falling dazed and sprawling on the pavement.

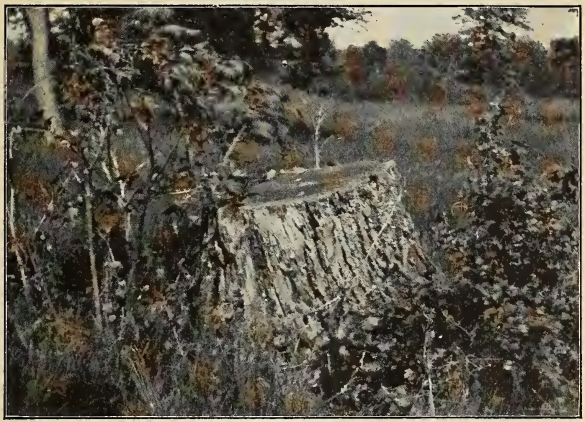


Fig. 39. An Old Decaying Stump Harbors Many Insects.

At such times hundreds of excellent specimens of these large insects may be collected and preserved in bulk for future use. By placing a lantern on the lawn we can attract many night-flying insects. The same happens if we leave a window open in a lighted room at night. Fireflies, of course, reveal themselves by their own lanterns.

A search through our houses from cellar to attic will result in a catch of insects and related animals somewhat as follows: In the damp cellar we find cellar-bugs, millipedes, centipedes,

ground spiders, and beetles. In the attic we find more spiders, on the rafters the homes of the mud-wasps and the paper-wasps. In the clothes-press, perhaps, there are moths.

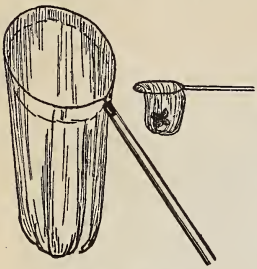


FIG. 40. Insect-Net.

Under the carpets are the carpet-beetles. Flies and mosquitoes are hard to keep out of the house. Ants invade the pantry. All these creatures come into the house in spite of the housewife's care and cleanliness. But if she is not so cleanly there may be cockroaches, fleas, and other more undesirable and less mentionable insects.

So there should be no difficulty in finding and collecting insects for nature-study. For this purpose the pupils should be provided with nets. The older pupils can make their own. An insect-net should be made of some light porous cloth, such as muslin, cheesecloth, or mosquito bar, made in the form of a sac about ten inches in diameter and about twice as long, fastened to a wire loop which is securely attached to a stick about four or five feet long. The dip-net may be smaller and should have a fine mesh. It is emptied by turning it inside out. Aquatic insects, to be kept alive, must be carried in water in pails or bottles. Cans, paper boxes, and bottles serve to bring back alive land insects for the school-room cages.

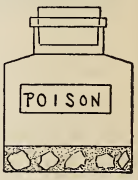


FIG. 41. Cyanide Bottle.

But if the insects are to be mounted, they are immediately killed by placing them in the cyanide bottle. Each pupil in the higher grades should have one of these. Take a wide-

mouthed bottle, like a vaseline bottle, and place some lumps of potassium cyanide in it. This can be obtained at a drug-store and is a deadly poison. On the lumps of cyanide pour a paste of plaster of Paris, and allow this to set or harden. The poison will give off fumes all the time, which rise through the porous plaster and kill the insects in the bottle. Label the bottle "Cyanide Bottle—*Poison.*" Keep it tightly corked. Leave the insects inside long enough to be surely dead. Larger insects, like butterflies, etc., may be placed under a larger vessel with an open cyanide bottle, or they may be killed with ether soaked in some cotton under a glass. Gasoline or kerosene poured upon them quickly kills them. In the field, butterflies may be quickly killed by tightly pinching the thorax for a short time. If left to flutter in boxes or bottles till taken home, they are liable to injure their wings by knocking off the beautiful scales. But, if killed in the field, they may be carried home uninjured in little packets or envelopes.

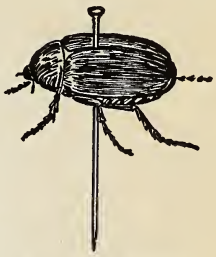


FIG. 42. Mounted Beetle.

The insects collected should be neatly mounted. This may be done by sticking pins through them after they are killed, and pinning them to the bottom of light boxes. Cigar boxes do very nicely.

The insects should be straightened out and arranged naturally, and pinned before they are dry. The wings, at least those on one side, should be spread out so as to display them. This applies to grasshoppers, locusts, beetles, bugs etc., which fold their wings when at rest. Moths and butterflies should be especially treated before mounting. Their

wings should be spread out and pinned or fastened in this position while drying. A drying board may be made, according to the figure, and the insect placed in the groove with its wings held down upon the side boards by means of strips of paper pinned down. Or they may be simply laid upon their backs on a board, and the wings spread out and fastened down. Very small insects, eggs, larvæ, etc., should be glued on the end of a strip of paper, and this pinned in the box. Do not crowd the specimens. Arrange them according to their natural relationships. Place the locusts, grasshoppers, and crickets together, the beetles by themselves, etc. If there is not sufficient room to write the names of the insects on the bottom of the box, simply number them, and write a corresponding list of names upon a slip of paper pasted on the inside of the cover.

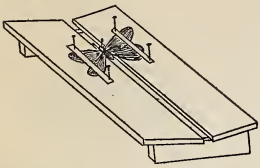


FIG. 43. Spreading Board.

It is better not to encourage primary and lower intermediate children to make collections, but leave this to older pupils, more interested in structure and classification. This collection should be made not merely for its own sake, but in order to learn something of the form, relationships, and habits of the insects. A mere collection that does not represent a study of these points amounts to very little. The habits of the insects should be observed, as far as possible, before they are caught and killed.

It is a good plan to collect insects of certain kinds in bulk, when they are especially abundant, and to preserve them in alcohol or formalin for future study. Thus, in a time of great abundance of locusts, or a pest of boxelder-bugs, or

when the electric-light bugs and ground-beetles swarm around the street lamps, it is an easy matter to gather a large quantity of these insects, which may be extremely useful for study in years when the supply is scarce.

It would be an excellent thing for the teacher to make a hobby of insect study. Let her take up some group like the butterflies, or the beetles, and collect and study them. In time she might become quite an authority on the class selected. Every teacher should have some kind of insect book for such work. Comstock's "Manual," Comstock's "Insect Life," Howard's "Insect Book," Kellogg's "American Insects," Folsom's "Entomology," and Holland's "Butterfly Book" are excellent.

Insects are fit subjects for study in any grade from the kindergarten up. Naturally, primary children are more interested in the general appearance, color, and habits of insects. Let them study the most common and noticeable insects: Flies, bees, moths, wasps, butterflies, locusts, crickets, June-beetles, fireflies, ants, etc. In higher grades touch more upon points of structure. Develop the structure of the typical insect. Note structural adaptations, such as feet, wings, and mouth parts, modified for special purposes. Note mimicry of shape and color, and point out the reason therefor. Study the metamorphism of insects. The habits should be studied, especially where productive of good or evil. All these things will make the study of insects interesting. Structure studied simply by itself is uninteresting.

In the upper grades, though also to some extent in the lower, insects should be studied comparatively, and simple relationships made out. The classification should be untechnical. Children should see that locusts, grasshoppers,

and crickets are closely related, and, similarly, the bees, wasps, and ants. They should be able to tell a bug from a beetle, a butterfly from a moth

Types of Insects

The meaning of the word Insect is frequently wrongly stretched so as to include creatures that are not really in-

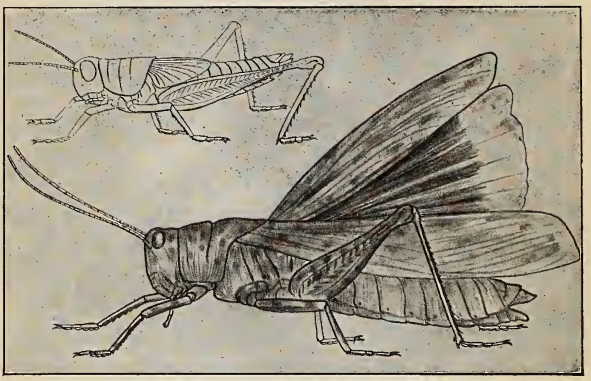


FIG. 44. Young and Old Locust.

sects. Thus spiders, isopods, and centipedes are called "insects," and even so very different an animal as the coral polyp is called by this name.

What is an insect? This is best answered by studying some typical insect, like the common grasshopper or locust.

The body is divided into three principal regions, the head, the chest or thorax, and the abdomen. The abdomen is composed of ring segments, and so is the thorax, though not so well seen. By bending the body it is seen to be jointed at the neck, between the chest and abdomen, and also between

the abdominal segments. This jointedness is a characteristic of all insects, and is extended also to the feelers, legs, and mouth-parts.

The grasshopper has six legs, composed of several stiff segments and a jointed foot terminated by minute forked claws that act like pincers and are used for grasping. The legs of insects are attached to the chest region, not to the abdomen, as sometimes seems to be the case. In the grasshopper the first two pairs of legs are not very strong, and are used for crawling and holding to a support. But the last pair are especially large and powerful, and are used for making high and long leaps. Observe how a locust uses his legs.

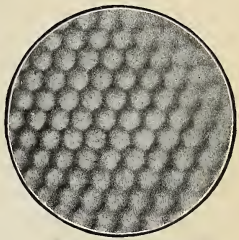


FIG. 45. Part of Compound Eye of a Dragon-fly.
(Photomicrograph.)

On the back of the thorax, from the second and third segments, arise the two pairs of wings, which the grasshopper folds up like a fan when not in use. The first pair are narrower and a trifle stiffer than the second, and protect the last pair somewhat when folded. Unfold the wings and examine them. Watch a grasshopper fly. In flying the wings are extended at the sides and expanded. The hind wings show bright colors in certain species. Hold an expanded wing up to the light, and see that it has a network of stiff ribs or veins running through the more delicate membrane. These act as a framework for the wings. The veins of the wings of insects are differently and characteristically arranged. Though grasshoppers are generally seen to fly only short distances, they have

the power of extended flight, and sometimes make long migrations.

The head of the grasshopper has a number of interesting organs. There are enormous compound eyes at the sides made up of many little eyes, or "facets." These can be readily seen with a magnifying glass. Besides the compound eyes there are three little simple eyes arranged in a triangle at the top and in the front of the head. In front of the eyes there are two jointed, tapering rods, called antennæ or feelers, which are sensitive organs by which the insect can feel and smell.

FIG. 46. Mouth-parts of Locust. (Photomicrograph.)

The mouth is a very complicated thing in most insects. In the locust it consists of the upper lip (seen in front), and behind it a pair of powerful biting jaws or mandibles (seen on the sides). Then follow two pairs of curious lobed appendages, called maxillæ, which serve in chewing and holding the food, and which have a pair of feelers. The last pair of maxillæ are grown together in the grasshopper and form what is called the under lip.

The body and legs of the grasshopper are covered with a tough, horny substance, which serves as a coat of mail against the stings and bites of other insects, and against mechanical injuries, and also as an external skeleton to give shape to the body and to permit the attachment and action of the internal muscles. This coating is technically called

chitin. It is the hardened epidermis of the insect. To permit the insect knight to move in his coat of mail, it is made in sections united by flexible bands similar to the jointed mail of old; and, as with human armor, so here the vulnerable spot is between the plates at the flexible membranes. This is where a wasp would insert her dagger.

The abdomen of the grasshopper is divided into ten ring segments, that fit together with flexible joints. On each side of a segment is a small pit or breathing pore. These pores communicate with a complete system of air-tubes that branch throughout the body, even into the veins of the wings. They are the lungs of the insect. Observe a grasshopper breathing. Note how the abdomen expands and contracts. By a muscular exertion the air is expelled, and the natural elasticity of the body-wall causes it to expand and draw in the air.

FIG. 47. Breathing Pore of a Cockroach.
(Photomicrograph.

The end of the abdomen of the female grasshopper has a forked appearance, on account of the projecting lobes. This arrangement is the egg-placer, or ovipositor, with which the female bores a hole in the ground and deposits her eggs in the burrow. The male's abdomen is blunt and round.

The fact that some insects, like the cricket, the grasshopper, and others, possess a call or "song" argues that there is a receptive organ for the sound. The ears, or hearing organs, of some insects have been located. The ear of the grasshopper may be found by lifting up the wings and looking at

the first abdominal segment. Here will be seen a shallow pit covered with an oval membrane. This curiously located organ is believed to be the ear.

In general, this description of the grasshopper is typical of all insects. As a class they have bodies divided into three sections, with abdomens distinctly segmented; they have three pairs of jointed legs, two pairs of net-veined wings, jointed feelers, compound eyes, complicated mouth-parts, breathing pores, respiration carried on in a system of tubes that spread throughout the body, and the chitinous coat acting as an external skeleton. It is true that in one respect or other many insects do not conform to this description. Some have no wings, some have lost one pair only, some have only rudiments of legs, etc. The immature forms of insects also often differ widely from this description.

Insects are hatched from eggs. The mother grasshopper lays her eggs in a mass in a barrow. The young are largely head, but the resemblance to the parents is unmistakable. The young grasshopper looks like a grasshopper from the beginning, even though it has no wings. There is no great transformation in passing through the different stages to maturity, and the adult period is reached when the wings are put on.

As the insect grows, its leathery coat becomes too small. It is then cast aside or moulted. This shedding of the skin occurs a number of times before the insect is full grown. Then, after the wings appear, no more moulting takes place. In moulting, a rent occurs in the cuticle, and the insect slips or wriggles out of the old coat. When first divested thus, the grasshopper has a pale, soft, moist skin. At this period the insect is especially vulnerable. Hence it generally performs

the moulting in some secluded or protected place. The soft skin allows the body to expand, but it soon hardens into chitin on the outside. The insect then proceeds to eat, and grows as long as its coat will stretch, when the moulting again takes place.

After several of the first moults fleshy pads begin to be noticeable on the shoulders. These grow with each successive moult, and at the last they are exposed and inflated with air and blood, and spread out into wings.[1]

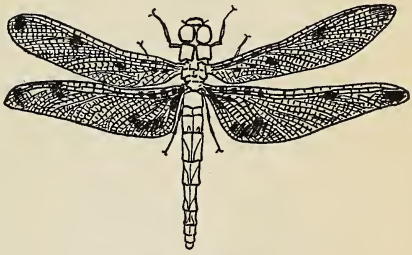


FIG. 48. Dragon-fly.

Insects are classified chiefly according to the structure of their wings and mouth-parts. Thus the locust, grasshopper, and cricket belong to the *Orthoptera*, or straight-winged group, so named on account of the narrow and straight fore-wings. There are about nineteen orders of insects, only six or seven of which need be referred to in nature-study. A typical insect of each of these orders, except the one already described, will be now considered:

Dragon-flies or Darning-needles are characterized by a long slender body, two pairs of narrow, net-veined wings always extended horizontally from the body, and enormous compound eyes. They are among the best flyers, flitting nimbly in search of insects to devour. They are sometimes called mosquito hawks, because of their predatory habits. Often

[1] For destructive effects of the locust, see pages 222–223.

dragon-flies are beautifully colored. Their eyes are finely iridescent, their wings mottled with blue, green, black, or brown spots and the abdomen similarly colored. The mouth of the adult dragon-fly is somewhat similar to that of the locust, and is adapted for biting and chewing, the mandibles being especially powerful.

Fig. 49. Dragon-fly Emerging from Nymph Case. Wings Not Yet Inflated. Below, a Nymph. (After Shipley and McBride and Packard.)

The dragon-fly is useful in devouring flies, mosquitoes, etc., and, in spite of popular prejudice, is perfectly harmless, without poison and sting.

The development of the young dragon-fly is very interesting. The female dragon-fly lays her eggs on the water of pools and ponds, where they hatch into rather hideous young, very different from the pretty gauzy-winged adult. The young dragon-fly is a heavy, flattened creature, brown or gray, looking much like the mud in which it lives. It has a large head, large eyes, and an enormous underlip that can be thrust forward to grasp its prey. There are two pairs of wing-pads upon the back. This ugly creature has, no doubt ironically, been called the "nymph." The nymphs may be found by dragging a dip-net along the muddy bottoms of ponds, and by lifting out and examining submerged leaves, sticks, and stones, to which they often cling.

The lower lip (second pair of maxillæ) is generally folded like a mask over the lower part of the face, but it can be suddenly shot out to seize mosquito "wrigglers" and other

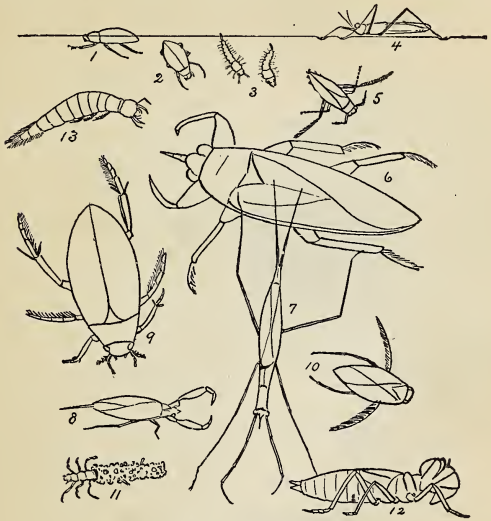


FIG. 50. Some Aquatic Insects.

1. Whirling-beetle.
2. Diving-beetle.
3. Mosquito Wrigglers.
4. Water-strider.
5. Back-swimmer.
6. "Electric-light" Bug.
7. Long-bodied Water-scorpion.
8. Short Water-scorpion.
9. Water Scavenger-beetle.
10. Water Boatman.
11. Caddis-worm.
12. Dragon-fly Larva.
13. Larva of Water-scavenger, Water-tiger.

aquatic creatures. With a pin or forceps, pull out the lip and examine it.

During its growth the young dragon-fly moults several times. When about ready for the final moult, the insect crawls out of the water upon the shore or on some projecting plant, then splits its nymph skin along the back, and emerges

an adult dragon-fly. But the wings are not yet expanded. They are mere fleshy lumps upon the back. The insect gradually inflates these fleshy masses until they become the beautiful, transparent wings. After waiting a short time for the wings to stiffen, the insect begins its swift, aerial life. Empty nymph cases are common sights along ponds and lakes.

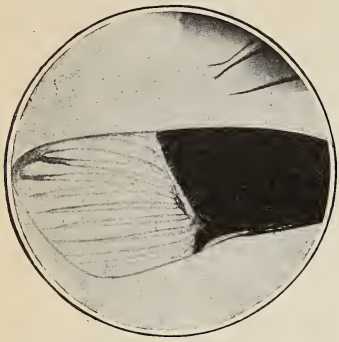


FIG. 51. "Half and Half" Wing of a Hemipterous Insect or Bug.

(Photomicrograph.)

This interesting emergence of the dragon-fly from the nymph may be observed by visiting a pond when these insects begin to be abundant. Or, better still, collect some of the nymphs about this time and place them in the aquarium, and you may be fortunate enough to see the whole process in the school-room. This development of the dragon-fly is called *direct*, and is not marked by a dormant period.

Damsel-flies and May-flies have a similar life history.

The Electric-Light Bug or Giant Water-bug represents another order. It is found in quiet pools and swamps, on the muddy bottom, or under submerged sticks and stones. At night it often leaves the water and, attracted by the arc lights of the streets, it may often be found in large numbers under the lamps.

The giant water-bug is one of our largest insects. It is about two inches in length, and is admirably adapted for the study

of insect anatomy. Note the large cross-folded wings. Lift up one of the front pair. It will be seen that the first half of the wing is thick and hard; the rest, thin and membranous. The under wings are thin and beautifully nerved. The legs are large and muscular. The hind pairs are flattened and fringed so as to serve as paddles. The first pair are modified into sharp grasping and piercing arms. This bug is a fierce, predatory creature, seizing and killing all kinds of aquatic insects, and even larger animals, like small fish, etc. It has a sharp-jointed beak, which it generally carries folded under its head, but which may be thrust into its prey. A poisonous fluid is also ejected through it, which paralyzes small animals and even causes painful wounds in those who handle it carelessly.

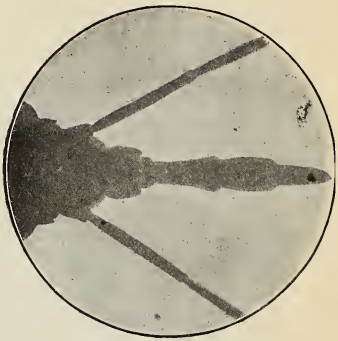


FIG. 52. Head and Beak of a Bug.
(Photomicrograph.)

During the youthful stage the bug has no wings, but otherwise resembles the adult, except in size. It is wholly aquatic at this time, but, during the mating season, the adults leave the water and swarm about at night. The eggs are laid in the water.

To most people the term "bug" is synonymous with the word insect, but to the entomologist the word means a distinct order of insects. Bugs, as a rule, have wings like the electric-light bug; that is, the outer pair are half hard and half mem-

branous. Hence they are called *Hemiptera* ("Half-and-half"-winged). Bugs have sucking and piercing beaks, which are very different from the mouth-parts of the locust. The young resemble the adults, except that they are smaller and have no wings. Bugs all live upon liquid food, the blood of animals, or the juices of plants.

The squash-bug, box-elder bug, chinch-bug, plant-lice, and

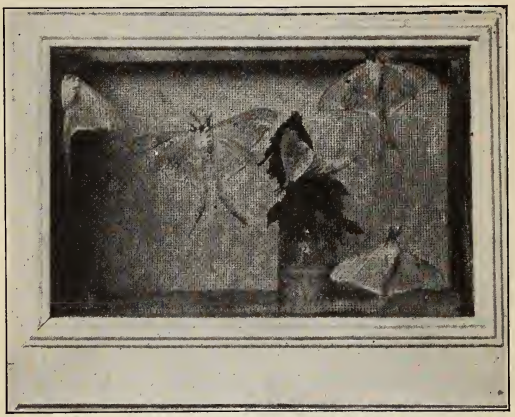


FIG. 53. A Cage of Luna-moths.

the common louse belong to the *Hemiptera*, and the cicada is also related to them. Some parasites, like the louse, have lost their wings from disuse. Some of the bugs, like the chinch-bug and plant-lice, are at times very numerous, and commit much damage to crops and other vegetation.

During the summer one of the most common butterflies is the common White Cabbage Butterfly seen flitting around our gardens. Perhaps you will see one of them alighting for

a moment on a cabbage or nasturtium leaf, then doing the same thing on another leaf, and so on. This is probably a female laying her eggs. Watch the insect carefully, and, after noting the leaf where she alights, examine for a minute the yellowish egg placed upright on the surface. Watch this egg for a few days, or cut off the leaf, and placing it in a glass of water observe the egg. It will soon hatch into a little green "worm" or, more properly, a caterpillar, which immediately begins to eat of the leaf on which it was born. This caterpillar is the baby butterfly, very different indeed from the beautiful winged form of the adult. It continues to feed and grow, shedding its skin periodically as it becomes too small. When full grown it is about an inch in length, and is covered with short, soft hairs. The caterpillar is divided into segments, but without any marked regional distinction. On the sides of the segments may be seen the small breathing pores.

FIG. 54. Insect Cage.

The head is small and mostly mouth, which is provided with a pair of strong mandibles for biting and chewing. There are no compound eyes, only several small, simple eyelets on each side of the head.

Examine the under side of the body. You will find on the first three segments next to the head a pair of short, jointed legs with clawed feet. These three segments correspond to the thorax of the adult. There also seem to be legs on other segments of the body; but closer examination will show that they are not real legs, but fleshy, wart-like outgrowths of the skin. They are called prolegs and are used for clasping. At the end of the abdomen there is one pair especially used for

clasping. Watch the caterpillar holding on to the edge of the leaf.

Cabbage caterpillars, all caterpillars for that matter, are very voracious. Their capacity can be judged by the havoc a few can effect in a head of cabbage in the garden.

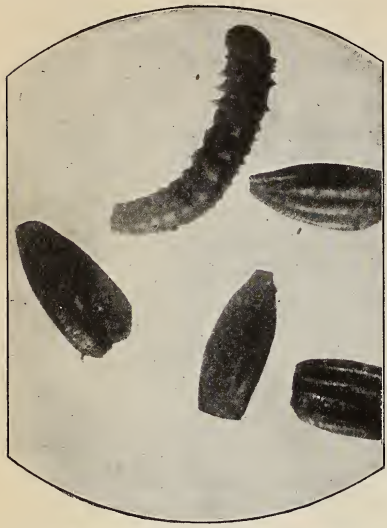


Fig. 55. Eggs and Young Caterpillar of Cabbage Butterfly. (Photomicrograph.)

The cabbage caterpillar moults several times before reaching full size, and at the final moult it seeks a secluded and dry spot, under the clapboarding or coping of a house, or under a board or leaf. It first fastens itself to the sheltering support by a tuft of silk at the tail, and also makes a sling of silk around the waist. Then a remarkable thing takes place. The old caterpillar coat splits and is cast off. But the insect no longer looks like a caterpillar. It is now a pointed, angular case, called a chrysalis. It remains in this form in a quiescent condition for several weeks, in the summer. In the fall of the year it may continue in this condition longer, and pass the winter as a chrysalis. It is apparently dead or asleep.

That it is alive may be shown by gently pressing it at the thick end, when the other end will wriggle. Apparently the insect in this chrysalis state is not growing or developing. Nevertheless, all this time wonderful transformations are going on within the shell. The caterpillar is being made over into a butterfly. Wings are developing. The legs become longer, the body becomes markedly divided into head, chest, and abdomen, the biting mouth of the caterpillar changes into the sucking tube of the butterfly, the simple eyelets become large and compound, and the rudimentary antennæ become long. Colored hairs and scales develop on the body and wings. These are the principal external changes in the caterpillar going on in the chrysalis. In the cabbage butterfly it takes two or three weeks to make this change, except in those which pass the winter in this condition. At the right time the chrysalis bursts and the winged adult butterfly comes out, at first with soft and crumpled wings, which, however, are soon inflated and dried. How different now becomes the life of the aerial, nectar-sipping butterfly from what it was in the voracious, leaf-eating, crawling caterpillar.

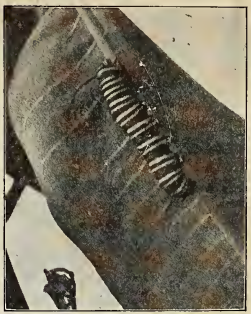


FIG. 56. Caterpillar on Milkweed Leaf.

FIG. 57. Getting Ready to Pupate.

Collect some nearly grown caterpillars and keep them in cages in the school-room. Feed them regularly upon fresh cabbage leaves. If possible, observe the moulting, the for-

mation of the chrysalis, and the emergence from it. Observe the way the caterpillar cuts away the edge of a leaf. See how its jaws work. Observe the way the butterfly uses his wings in flight and rest. Note how the wings are held up over the back and folded together when at rest. Place some flowers or a dish of sweetened water in the cage, and see how the insect uses its long proboscis or sucking tube. What does it do with the tube when not in use?

Fig. 58. Chrysalis of Milkweed Butterfly — Green and Gold.

The butterfly passes through four distinct stages: the egg, the *larva* or caterpillar, the chrysalis or pupa, and the *imago* or the adult. This kind of growth is called indirect development or, perhaps better, complete metamorphism. Compare with the locust. Other insects besides the butterflies have this kind of development, where the different stages are strikingly different from each other, such as the fly, beetle, bee, and ant, for example.

Fig. 59. Milkweed or Monarch Butterfly Just Out of Chrysalis.

Moths and butterflies belong to the order of *Lepidoptera* (Scale-winged), so called because of the colored scales on the wings. These scales are arranged like the shingles on a roof. The fine mealy substance that rubs off on the fingers when a moth or butterfly is handled consists of these scales.

Moths are chiefly nocturnal insects, and may be distinguished from the butterflies by the fact that they hold their

wings flat over the body or extended laterally, and not erect over the back like the butterflies, when at rest. They also have, as a rule, thicker and heavier bodies than the butterflies. They have thread-like or feathered antennæ, while butterflies have feelers with thickened or even knobby ends. Their food is like the butterfly's.

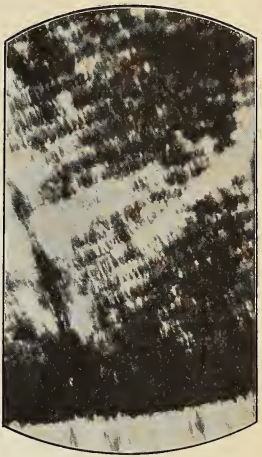


Fig. 60. Scales on a Moth's Wing. (Photomicrograph.)

Moth-caterpillars generally spin a silken case or cocoon around themselves before going into the chrysalis stage. Collect some of the black and brown woolly Tiger-caterpillars and rear them in a cage till they spin their cocoon. The silk comes from glands within the body and emerges near the mouth. It is a liquid that quickly hardens on exposure. To escape from the cocoon when the transformation is complete, the moth dissolves the gum that binds the fibres of the cocoon together and forces its way out.

Examine a cocoon. Open it. Within you will find the chrysalis and the last caterpillar coat.

There are many harmful moths: tent-caterpillars, clothes-moths, army-worms, cut-worms, codling-moths, gypsy-moths, etc.

The Beetles or *Coleoptera* (Sheath-winged) represent another great order of insects. A good typical beetle is the common June-"bug" (beetle). This is a common night-

flying insect, often found in great swarms in early summer. It has a short, fat body. The abdomen is covered with two stiff, hard, concave wing cases, which are really modified wings, the first pair. They serve not so much for flight as for protection in general, and to cover the delicate under-wings. The hind pair of wings are tucked away under the wing cases, and are folded first lengthwise and then crosswise.

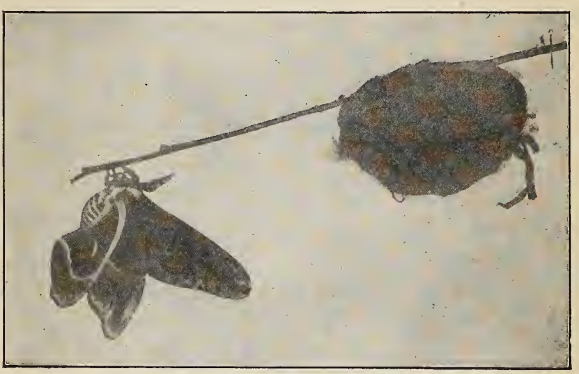


Fig. 61. Cecropia-moth Just Out of Cocoon.

It is the outer pair of hard wings that gives this order the name *Coleoptera*.

Beetles have mouths much like those of locusts, and the mandibles (jaws) are especially strong and large. They feed on a great variety of food. Some are carnivorous, and some eat various parts of plants.

The young stage of the beetle is called the grub. That of the June-beetle is known as the Common Grub-worm. It is the fat, white, fleshy larva, the kind used for fishing, found in

manure piles or rich soil. This caterpillar-like larva, with a hard head and chewing mouth-parts, a soft, segmented body, with feet like a caterpillar, but no prolegs, lives on delicate roots of plants or on decaying organic matter.

Most beetle-grubs pass into pupæ, the quiescent stage, which is a sort of chrysalis in which the wings are in separate pouches and the legs are free. The June-beetle spins no cocoon, but hollows a cavity in the ground, which it lines with an excretion that makes a kind of shell around it. In the spring and early summer the insects emerge from their pupal

FIG. 62. Caterpillar Beginning to Spin Cocoon, and Finished Cocoon.
A. Old Caterpillar Coat. *B*. Chrysalis.

cases in adult form. They often come in such numbers that they do considerable harm to the foliage of trees. The grubs also of certain kinds of June-beetles do harm in the gardens, by eating the roots of plants. In the daytime the June-beetles hide, sometimes in the foliage of trees, and they come out at night, flying about in a blundering way seeking for their mates.

Beetles are well adapted for living under various conditions. There are many varied forms, and they number about 100,000 species. Their stout mouth-parts adapt them to all sorts of food. Many are quite injurious. Meal-worms (beetle larvæ) spoil flour and grain. Potato-beetles destroy the foliage of potatoes. Cucumber beetles eat squash, melon, and cucumber vines. Rose-chafers destroy our roses. Wood

and bark-boring beetles are injurious to trees. Carpet-beetles destroy our carpets. Tiger-beetles are active and feed upon other insects, and so does the little polka dotted ladybug. The large, black water-beetle also feeds on other insects. The goldsmith's-beetle is a handsome cousin of the June-beetle. The fire-fly is also a beetle.

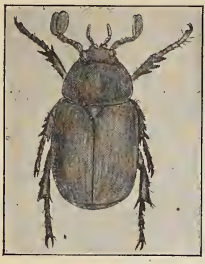


Fig. 63. A Beetle.

Flies, Mosquitoes, and Crane-flies form another order, the *Diptera* (Two-winged). The name refers to the fact that these insects have only one pair of fully developed wings, the hind pair having become rudimentary.

The House-fly is typical. This insect lays its eggs on decaying manure or exposed meat, etc. Very soon small, white, footless larvæ hatch out, which are called maggots, and feed upon the substance in which they are hatched. After about a week the maggots shrink into barrel-shaped pupæ (corresponding to the butterfly chrysalis), from which after another week the adult winged flies emerge.

Fig. 64. Head and Mouth-parts of a Predacious Beetle. (Photomicrograph.)

The fly has a rather large head, connected by a very flexible neck to the hairy thorax. This is well marked off from the

short conical abdomen. It has six stout legs, with five-jointed feet, which have a pair of pincer claws at the end and a pair of pads underneath.

These pads are beset with hairs, from which exudes a sticky substance that enables a fly to walk upside down on the ceiling. The gauzy wings are not folded over each other, but

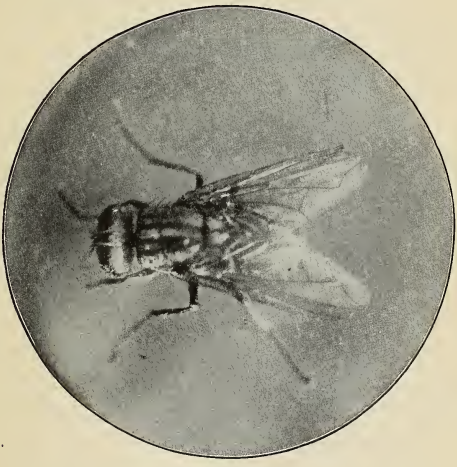


Fig. 65. House-fly.
(Photomicrograph.)

are laid flat against the back and reach beyond the body. Examine a fly closely and you will find a pair of small, curved, rod-like organs in the place where the second pair of wings ought to be. In fact this is all that is left of the second pair. They are called halteres and may serve to rest the front wings upon while soaring. In some species of this group the second pair of wings is represented by a pair of

slender rods, as can be very nicely seen in the long-legged crane-flies.

The large compound eyes of the fly are very prominent and his sight is good. Try to catch a fly.

The mouth is very complicated in structure — varying in different kinds of flies and the other genera of the order. In the house-fly the mandibles and maxillæ are aborted, but the lower lip is a curious, extensible organ, called a tongue or proboscis. It is usually folded up under the head, but when in use it is thrust out and opens up into two lobes, which are

FIG. 66. Honey-bees: Drone, Queen, and Worker.
(From Benton.)

rough, like a file or rasp. With this rough tongue the fly can scrape off bits of meat, bread, etc., and lap up liquids. Place a little dry and liquid food for some flies to eat, and observe the use they make of their tongues.

There are many species of flies. The most common is our house-fly, but there are meat-flies, bluebottle-flies, fruit-flies, horse-flies, deer-flies, etc. Some of these have mouth-parts adapted to piercing and sucking, as in the case of the last two.

Adult winged insects do not grow and moult the skin. Hence the small flies we see are not young house-flies, but belong to another, smaller species.

The house-fly is an immigrant from Europe, probably

brought over by our first colonists. It is a great nuisance about the house. It gets into our food, specks up everything, wakes up the baby, etc. But worse than this, it often is the carrier of disease germs. First it walks in infected filth and then over our food, infecting that, and this in turn transmits the germs to us. Clean premises, screens, mosquito bars, and fly-paper are efficient remedies against the house-fly.

Flies live for several months and then most of them die from the cold of autumn, or from a disease caused by the fly-fungus. Flies attacked by this fungus may often be seen on the window-panes, covered and surrounded with a cloudy substance. A few flies manage to live or hibernate through the winter, to come out in the spring and renew the race.

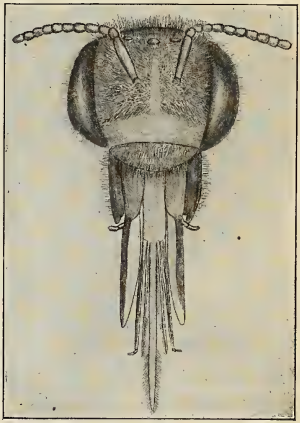


FIG. 67. Head of Honey-bee.

Bees, Wasps, and Ants constitute another great and very important order, the *Hymenoptera* (Membrane-winged.) The bee and the polistes-wasp make good types for study. If the bee is chosen, a study of its anatomy will reveal the following facts: The body is hairy, often colored black and brown or yellow in bands. The abdomen is joined to the chest by a very narrow, "wasp-like" waist. The six legs are strong, and well adapted for climbing and clinging on flowers. The first joint of the hind foot is flattened and beset with hairs.

It is used for gathering pollen, and the tibia, the lowest segment of the same leg, is used as a basket to carry the pollen to the hive. It is provided with long curving hairs for that purpose. Bees are frequently seen in the field or coming home to the hive, with their pollen baskets filled with golden dust.

Fig. 68. Sting and Poison Bladder of Honey-bee. (Photomicrograph.)

The wings of bees are very transparent, with but comparatively few veins. The fore and hind wings are fastened together by means of minute hooks along their adjacent edges. These interlock and make the wings more rigid. Bees are excellent flyers.

The mouth-parts are very complicated. There is a pair of rather weak chewing mandibles, a pair of sharp maxillæ for piercing flowers, and the lower lip is peculiarly modified into a hairy, hollow tongue, adapted for sucking or lapping up the nectar of flowers. It lies between the second pair of maxillæ.

The bee, as is well known, is provided with a formidable sting. This is a modification of the ovipositor. Connected with the sting is a poison-gland from which the bee injects into the wound formic acid, which causes an irritating inflammation.

The above description applies to the worker-bee. There are two other forms, the queen and the drone. The drones are the males, and can be distinguished by their greater plumpness and hairiness. The queen is the mother of the drones and of the workers, and has a body which is longer

and more pointed than the others. Workers are incompletely developed females and are unproductive.

The workers do all the work of the hive except laying the eggs. They make the honey, gather the pollen, build the honey-comb, nurse the young, etc. The drones lead a life of idleness, and their only function in the colony is to fertilize the queen for the egg laying. There is generally only one queen to a hive, several hundred drones, and 10,000 to 40,000 workers.

Bees are social insects, with a wonderfully intelligent community life. There is among them a division of labor, a careful nursing of the young, a remarkable skill in the building of the comb, and a regulation of the colony life that amounts to an excellent organization.

The active life of the hive is resumed in the warm days of spring, when the flowers again offer their fragrance, pollen, and nectar. Then the queen and such workers as have withstood the hardships of the winter bestir themselves. The workers clean the hive, and gather nectar and pollen. The queen lays eggs to increase the population of the hive. She may lay several thousand per day. The number of eggs, however, varies with the food supply, being smaller in seasons of scarcity of food. The eggs are placed by the queen in special brood cells, which are generally in the central part of the hive. Here the young are hatched into helpless little larvæ, which are fed and cared for by the workers, till they are ready to turn into pupæ. Then the workers wall them up in the cells, and the pupæ remain dormant for a period, developing into the winged form. Most of them turn into workers, a few into drones, and still fewer into queens. The larvæ in the queen cells are given especially rich food.

All summer long the honey is stored up in the combs, which are made of six-sided cells in two layers, end to end. The wax is an excretion sweated out of the pores between the abdominal segments of the workers. This they scrape off with their feet, and knead and work into comb with their jaws.

Fig. 69. Hornet's Nest.

Honey is more than the nectar gathered from the flowers. The bee takes the nectar into its honey-crop, not stomach, where, though it does not undergo digestion, it is in some way changed so that it is different from the nectar. This is disgorged into the cells of the honey combs, and the bee adds a small amount of formic acid as a preservative. It is also probable that some water is removed from the nectar while it is in the crop. The honey is further condensed in the cells, and most of the volatile oils are evaporated from it. Then the cells are sealed with a cap of wax. The honey generally retains some of the aroma of the flowers from which the nectar was collected. Thus we can distinguish basswood, clover, or buckwheat honey. The bees confine themselves chiefly to the principal flowers out at different times, so the honey is pure rather than mixed in the combs. Among the flowers visited by bees for pollen and nectar are those of the willow, maple, currant, fruit trees,

common locust, raspberry, white clover, alsike clover, basswood, sweet clover, buckwheat, wild aster, and goldenrod. Bees range several miles in search of flowers and use the pollen extensively for food, especially for the brood. They keep it stored in cells.

Bees also collect the gummy juice that exudes from some trees, such as the plum and cherry, This substance is called propolis, and is used for cementing up the cracks of the hive.

FIG. 70. Brood Comb Inside a Hornet's Nest.
(The capped cells contain larvæ.)

In the work of collecting pollen and nectar the bees perform a great service to plants. They carry pollen from one flower to another, and thereby bring about what is called cross-pollination, which results in fertilization of the ovules and the formation of seed and fruit. An apiary in connection with an orchard is a very practical and profitable arrangement.

In early summer when things are going well in the hive, honey is abundant, the colony has increased to uncomfortable size, and new queens are nearly ready to emerge from their cells, the old queen leaves the hive, followed by a large part of the workers in search of a new home. Generally she first alights on the branch of a tree or shrub, and the

workers cling to her and each other in a dense cluster. They may now be shaken into an empty hive and thus prevented from wandering off. This leaving the old hive is called "swarming."

Soon after the old queen has left the hive the new queens hatch out. Often the first out will sting the others to death in their cells or in combat. Sometimes the extra queens swarm away with some followers. Finally one queen is left mistress of the hive. Then she goes out with the drones on a wedding trip, but soon returns to the hive to proceed to her duty of laying eggs. The drones are mercilessly killed by the workers in the fall, or when the food begins to be scarce.

During the winter the colony lives on the store of honey in the hive.

Many swarms of bees leave the apiaries and take up quarters in a hollow tree or a rock cavity. Some people make it a practice to trace these homes of the "wild" bees, which may be done by following the "bee line" or direction taken by the laden bee on its way home. Read Burroughs' "An Idyl of the Honey Bee," which tells about bee hunting.

The interesting life in the colony may be observed by school children by visiting an apiary and having the bee-keeper show and explain things. A still better method is to have an observation hive with glass sides.

CHAPTER XIV

INSECTS, HARMFUL AND OTHERWISE

From a human point of view insects have a great economic importance. They are either useful or injurious. Many are direct pests and nuisances. They frighten or disgust us; they annoy us, like the flies; or they bite or sting us, like the gad-flies, fleas, mosquitoes, and "yellow jackets."

But the most harmful insects are injurious to man only indirectly. They eat his crops, spoil his fruit, and injure his trees and flowers, his books, furniture, and clothing. They go into the pantry and make havoc there. The bot-fly and the tsetse-fly kill his cattle. The losses inflicted by insects in these various ways often amount to millions of dollars yearly.

Mosquitoes belong to the two-winged group. These little insects can entirely spoil our enjoyment of outdoor life at water resorts, in the woods, or even on the city veranda.

The natural breeding places for mosquitoes are swamps and marshes, though rain barrels, puddles, tin cans, etc. will do. The female lays on the water, a boat-shaped mass of eggs, which floats around till the eggs are hatched. The larvæ of mosquitoes are commonly known as "wrigglers," and are frequently seen in rain barrels. Wrigglers breathe air by means of a tubular organ near the posterior end of their bodies. When at rest they are at the surface of the water,

head down, with the breathing tube thrust up through the surface-film and adhering to it. If they are suddenly disturbed, they quickly fall to the bottom.

The larva changes to a bent form, the pupa, which breathes air by means of thoracic spiracles. It now has wing pads. This pupa finally splits open on the back, and the winged mosquito appears, using the old pupal case as a raft until its wings are strong enough to fly. All these changes

FIG. 71. Mosquito.

take place in a few days, if the conditions are favorable, and they are interesting to observe in the school-room. Keep a number of larvæ in a dish of water with a screen over it. Watch frequently, and probably you will see the mosquito emerge.

The male mosquito differs in appearance from the female. He has long feathery antennæ, believed to be organs of hearing, and he has no sting or, rather, beak. Therefore he does not "bite" as does the female. She has smaller antennæ, and her mouth-parts are a collection of slender, sharp, piercing,

lancing and sucking organs. They are modified mandibles and maxillæ, which can be folded together into a sucking tube. The female "sings," but the male is silent.

In many places malaria is a burden to the people. It is now believed that mosquitoes carry the germs of the disease, and implant them in man when they bite. It is not the common mosquito, *Culex*, that is responsible for this, but the genus *Anopheles*. This genus may be distinguished from

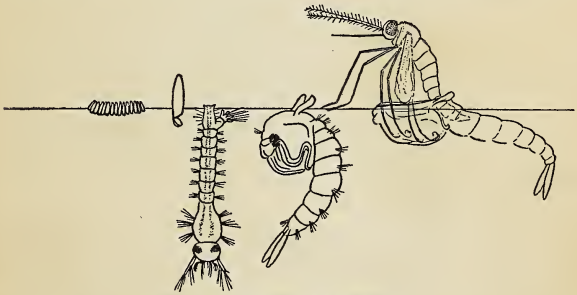


FIG. 72. Development of a Mosquito.
Egg mass, enlarged egg, hatched out larva, pupa, and adult emerging from pupa case. (After Howard, Miall, etc.)

the common mosquito by the fact that it seems to stand upon its head when at rest, while the common form stands as a well-behaved mosquito should, with the body parallel to the resting surface.

It has also been determined that the mosquito is a carrier of yellow fever. After biting a fever patient a mosquito bites a healthy person, who then contracts the disease.

These facts make the checking of the development of the mosquito a very important problem. Screens on doors and windows are very effective in keeping them out of the house.

The most successful way to exterminate the mosquito is to pour a little kerosene oil upon the water of their breeding places. This forms a thin film over the water and kills eggs, larvæ, and adults that come in touch with it. This method of extermination has shown good results.

Fish, tadpoles, and aquatic insects destroy many wrigglers, and the adults are eaten by other insects, especially dragon-flies, by birds and bats.

The Flea is another very troublesome insect, found in the homes of prince and pauper. The bite of this little tormentor is more painful, and in many people leaves more lasting and irritating inflammation than that of the mosquito. There are many different kinds of fleas, but the most common in this country are the dog-flea and the cat-flea. The human-flea, so common in Europe and the Orient, is as yet not numerous here except locally.

Fleas are related to flies. They have lost their wings from disuse, however, and they have no compound eyes, only two simple ones. They have a sharp beak with which they suck the blood of animals. They are very hard to catch, as they are very nimble and excellent jumpers. They lay their eggs in dust in the cracks of the floor. Cleanliness in housekeeping is the best remedy against them. Dogs and cats with fleas should not be allowed in the house.

Similar parasites are Lice and Bed-bugs, belonging to the Bugs. They have lost their wings on account of their parasitic, lazy habits. These creatures are often distributed in schools, in the cars, at moving times, and on the street. They are very irritating pests that thrive in dirt and filth. Personal cleanliness and a liberal use of soap, broom, scrub-brush, scalding, and treatment by gasoline of the rooms and

furniture infested are preventives as well as remedies for them.

Another disgusting household insect is the Cockroach, of which there are several kinds. The small kind is called the Croton-bug or German cockroach. The large, black kind is the Oriental roach. They are hard to get rid of. They are unpleasant to meet with in the night; they run over the food in the pantry, and congregate in cracks and crevices near sinks and drains. The most effective remedy for them is probably to pour gasoline or carbon bisulphide into their hiding places. They are sometimes caught in cockroach traps. The eggs are laid in cracks in little bundles, which the female may sometimes be seen carrying about with her.

Clothes-moths (several species) are very destructive of wearing apparel, tapestry, carpets, etc. Many a fine fur garment, or cloth suit, has been ruined while being stored during the summer or left uncared for in a closet or trunk. Clothes-moths have been associated with man for ages. The Bible speaks of treasures that moths do not corrupt, and Job is made to speak of "a garment that is moth eaten."

The common clothes-moth is a small, buff-colored moth, about half an inch in length. In the summer this moth lays her eggs upon clothing, and the larva or caterpillar that hatches out of the egg begins to eat off the nap of the cloth or the hairs of the fur, and proceeds to make itself a felt case. This it carries around with itself, and enlarges when too small by adding to the end, and to make it wider puts in gores. Then it turns around in the case and does the same at the other end. The case is further lined with silk spun by the larva itself. The caterpillar lives on the material of the garment or the dirt that may be on it, and passes

the chrysalis stage in the case. Finally the winged moth emerges.

The moths themselves are harmless, but they lay the eggs that become the destructive larvæ. The moths may be prevented from laying their eggs in clothing by putting it in well sealed paper packages, or in tight boxes or chests. The insects, that is the adults, do not like the odor of moth balls and camphor. Hence these substances are usually put in the chest or package in which the clothes are to be kept. Cedar chests are also avoided by moths. All these precautions are useless, however, if eggs have already been laid in the garments before they were put away. Therefore it is well to brush out well and air the clothing before packing it. Another way to prevent injury from moths is to put the furs, etc., in cold storage; if any eggs are in them they will not hatch.

Our gardens suffer from several kinds of insects. Early in the growing season Cutworms are troublesome. They cut off the sweet-peas and other tender plants near the ground, and drag the plant down into the burrow generally close to the base of the plant, where, if we dig, we can generally find the culprit. This cutworm is a fleshy, gray, black-striped caterpillar, which crawls about at night. It is the larva of a moth. The best preventive against it is to put a little fence or girdle of stiff paper or boards around the plant or the beds. Poisoned bran is a bait they will eat. Birds and toads are good friends of the gardener and destroy many cutworms.

Cucumbers and squashes are injured by the Striped Cucumber-beetle and the Squash-bug. Paris green and ashes are a remedy against them.

A very injurious butterfly is the little white Cabbage But-

terfly, seen flitting about every garden from early spring till late in fall. The eggs are placed on cabbage, cauliflower, and nasturtium leaves. The caterpillars are very voracious and often do much damage. Pyrethrum powder (insect powder) is a remedy. This butterfly is not a native species, but was introduced from Europe about 1860, since which time it has multiplied enormously, having two or three broods a year. A small ichneumon-fly is its parasite, which in a measure acts as a check to it.

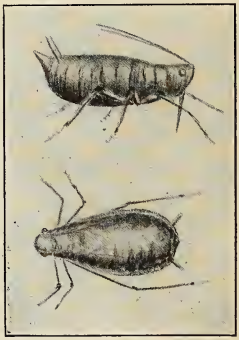


Fig. 73. Plant-lice.

Plant-lice or *Aphides*, of which there are many species, are harmful to many plants. They are minute insects, and their permanent location on certain plants amounts almost to parasitism, so much so that most of them have no wings. They are usually named after the kind of plant on which they live: cherry aphis, peach aphis, corn aphis, hop aphis, etc. They are generally crowded together in great numbers on the succulent twigs and leaves of plants. They live upon the juices of the plant, which they suck through piercing beaks.

Some aphides are green; others, black; some, red. Some are covered with a woolly coat. Some have a pair of little rods at the rear end of the back. These aphides excrete a sweet liquid, which often drops from them upon the leaves and the walks beneath the trees. This liquid is called honey-dew, and is relished by certain ants, which may often be seen in summer among clusters of black aphides on the

lamb's-quarters weed. The ants climb up the weeds to the colonies of aphides to lick from them the excreted honey-dew. These honey-dew forming plant-lice are sometimes called the ant's cows. Bees and other insects also sometimes drink this liquid. The honey made from this, however, has an inferior and rank quality.

Plant-lice can weaken or even kill plants by robbing them of their juices, House-plants, such as chrysanthemums, are subject to the attack of these insects and are much injured. The aphides feed chiefly on the stems and leaves, but some of them attack the roots of plants. Garden asters are often killed in this way. The phylloxera is such an aphis, and at one time almost ruined the grape industry of Europe.

Kerosene emulsion, and fumigation with tobacco and carbon-bisulphide are common remedies. Soap and sulphur solutions are also used to destroy plant-lice.

For study, either observe the colonies on different plants outdoors, or bring plants or parts of infested plants to the school.

Orchards with their sweet-scented, nectar-filled flowers, tender foliage, juicy bark, and luscious fruit always attract many injurious insects. The plant-lice referred to are sometimes very troublesome to fruit trees, the apple being especially attacked at the roots.

Related to the plant-lice are the Bark-lice or Scale Insects, so called from their habit of clinging closely to the tender bark of trees and sucking the juices, also from the scale-like appearance of the female insects, which generally are covered with a rounded, protecting scale. We sometimes find upon the leaves of the palm and other greenhouse plants white, flaky spots, which on close examination are seen to be insects called

mealy bugs, a species of scale. On many fruit and other trees there often form dense incrustations of scale insects that sometimes kill the trees. The apple-bark louse is such a one. The San José scale, that affects the orange and many other fruit trees, has done a vast amount of damage. The best remedy for such insects is spraying with emulsion. Fumigation with hydrocyanic acid gas is also used.

Another serious menace to all orchards is the Bark and Wood Borers. These are the larvæ of various moths and beetles, that gnaw their way through and live upon the tissues of the bark and wood of stems and roots. Apple and other fruit trees, the box-elder, basswood, and many other trees will show upon their bark many holes. These were mostly made by woodpeckers digging for borers. With a strong knife or other tool chip the bark from some old box-elder tree, and you will no doubt find some bark borers that have made tunnels between the bark and the wood. On peach and cherry trees there may be fresh masses of exuding gum, which indicates the presence of borers, and cutting into the bark will reveal the larvæ. The best remedy we have against these borers is perhaps the woodpeckers, which should be encouraged in every orchard. Wrapping the trees is sometimes an effective remedy.

The Codling-moth ravages apple orchards. Soon after the petals fall from the flower the moth lays her eggs in the calyx of the flower or, rather, young fruit. The larva that hatches out bores its way into the core of the apple. The affected apples fall early, and the grub bores its way out and generally crawls up the trunk of the tree, to make its cocoon under the bark scales. A second brood generally affects the orchard again later in the summer and causes many apples

on the market to be wormy. Millions of dollars worth of fruit are lost annually through this insect. Early spraying with poisons will kill the larvæ. Collecting and destroying the apples that fall early, wrapping straw, etc. around the trunk for the caterpillars to make their cocoons in, in order to collect and burn them, are remedies. Birds in the orchard are a great aid.

Fig. 74. Tent of Web-worms.

A number of other caterpillars injure the foliage of orchard and shade trees. The Tent Caterpillar forms large, unsightly webs in the twigs of the trees. These webs are the homes of several hundred caterpillars, that were hatched out of an egg mass deposited by the female moth the fall before, on the twigs near the tent. These caterpillars feed upon the leaves of the trees, and by the defoliation sometimes injure the trees materially, besides disfiguring them badly. They eat the soft parts of the leaf, leaving the skeleton of ribs and veins. They generally feed during the early morning hours and again toward evening, probably so as to escape the attacks of other insects and of birds. During most of the day they hide in

the tent, which is a good protection against many of their enemies. At night it helps to protect them from the cold, and it also sheds rain. As the caterpillars crawl about on the tree they spin out a thread of silk over the path they take. This may aid them in finding their way back to the tent, and also enables them to let themselves down from the branch or leaf to the ground. After reaching maturity the caterpiller crawls or spins down from the tree, and seeking shelter under sticks, stones, bark, etc., goes into the cocoon or pupa state. From this emerges a dusky, streaked moth. The nests should be removed with the colony as soon as noticed, and should be burned. Birds are useful in ridding us of this pest, especially the winter resident woodpeckers, chicadees, nuthatches, etc., which eat the eggs. The cuckoo and oriole destroy many of the caterpillars in summer. Most birds do not like the hairiness of the common tent caterpillars and hence leave them alone.

The forest trees are affected like the orchard and shade trees. Large tracts of forest are sometimes defoliated by tent caterpillars, canker-worms, tussock-moths, and other leaf-eating caterpillars. Leaf mining or eating beetles also do much harm to the foliage. The borers injure the bark and wood of the stem and roots. Gall-forming insects attack many forest trees and injure the leaves and twigs. In fact, it is often impossible to find a perfectly sound leaf in the latter part of the summer, so widespread is the injury done by insects.

The farmer has some very bad insect enemies to contend with. Potato-beetles, chinch-bugs, army-worms, weevils, and locusts sometimes cause the ruin of prosperous farmers, so that such an insect plague becomes a national calamity.

The Locusts or Grasshoppers, as they are commonly called, are perhaps the most serious of these pests. References to locust plagues are found in ancient history and the Bible. The locust plague in Egypt in Bible times "covered the whole face of the earth, so that the land was darkened; and they did eat every herb of the land, and all the fruit of the trees which the hail had left; and there remained not a green thing in the trees, or in the herbs of the field, through all the land of Egpyt." The same has happened in Kansas and other states within the memory of man.

There are a number of species of locusts in this country, but the one most commonly seen in the North is the common Red-legged Locust, with red legs and wings no longer than the body. This rarely does much harm to crops. It is a common insect along the roadsides and in the meadows. The Rocky Mountain Locust is similar to this, except that its wings are longer. This species lives chiefly in the dry plateau region of the United States, but occasionally migrates to the agricultural sections farther east. There it sometimes does immense harm, and reduces states to the verge of starvation, as in Kansas in the year 1874. The Clouded Locust is a common pasture insect, that makes a snapping sound by rubbing its wings together as it flies. The Carolina Locust is a common gray or brown locust, seen often in dusty roads or along the sandy shores of lakes and rivers. It is rather large, and is hard to see at rest because its color resembles the background. Its under wings have a bright band of orange or yellow, which is displayed in flight. In the Middle South there is the large Bird Locust, measuring over two inches in length.

I remember one locust year in Minnesota, when the locusts

settled irregularly on the country, visiting certain regions and leaving others unharmed. They ate the ripening wheat and other grains; they attacked the corn and every other green plant; they congregated in swarms along the roadsides, and clustered thickly on the fences at night or under piles of straw and other litter. In the latter part of the summer, one could dig almost anywhere along the roads in the hard soil and unearth their egg masses, or see the females burrowing the ground to deposit their eggs. After doing much harm the locusts suddenly, and with almost one accord, took to the wing and flew away. So thick were they in the air that on looking up one saw the myriads of locusts like flakes in a snowstorm, and the sun was actually dimmed by their great numbers. Soon after news came of great masses of locust bodies having been found in the Atlantic Ocean along the coasts. The farmers fervently hoped they were those of their late enemies.

Various remedies were used to fight the plague, but most of them were as a drop in the bucket. The insects were crushed on the fences, coaxed into rows of litter which were then burned. The young were collected along the roadsides by pushing a small tar-covered cart about in the grass. The young locusts jumped into the tar and were afterwards burned. Fortunately locusts, like other creatures, are subject to natural enemies and diseases. Many kinds of birds eat great numbers of them. Reptiles, frogs and toads, field mice, shrews and moles eat them. There are certain insect parasites that kill or weaken them. On many locusts you may find attached to the wings and other parts of the bodies small red mites. The common hair-worm (hair "snake") is an internal parasite of locusts. Certain fungous diseases affect

locusts, so that often great numbers of them are stricken. The eggs and young of the Mountain Locusts do not thrive well in the lowlands and soon die out. Thus, there are natural checks upon these rapacious hosts.

Many other kinds of insects are very injurious to the farmer's crops, notably the army-worm, chinch-bug, potato-beetle, cotton-boll weevil, etc.

Not only the farmer's crops, but his animals as well suffer from insects. There are many species of flies, mosquitoes, gnats, lice, ticks, mange insects etc. that irritate and injure his horses, sheep, and cattle. Poultry also suffers much in the same way. External scabs and internal bot-flies, if neglected, may result in the death of the animals so affected. In South Africa there is a fly called the Tsetse-fly that introduces with its bite a disease germ that kills cattle and even man.

The United States Department of Agriculture, and the Agricultural and Experiment Stations of various states have departments of entomology for the study of harmful insects and ways of controlling them.

Insects and Flowers

There exists a very intimate relation between flowers and insects. A few minutes spent in watching a flower-bed or a patch of wild flowers will show flies, bees, bumblebees, moths, and butterflies, as well as other kinds of insects, crawling into or over the flowers, sipping the nectar, or eating and gathering the pollen. These insects are doing a great work in nature—carrying pollen from the stamens to the pistils of the flowers. This is called pollination, and is an essential thing in the formation of fruit and seed. It is an interesting fact that if a

flower be pollinated, not with its own pollen, but with that of some other flower of the same sort, better seed will be formed. It seems to be the aim of nature to bring about cross-pollination, as this is called, in one way or another. And one way is to utilize insects.

It may be set down as a general rule that all flowers that have bright colors, nectar, and perfume are insect pollinated. The colors and odors attract the insects, and they like to drink the nectar. The pollen also is eaten by many insects. The insects travelling about from flower to flower carry, not intentionally but accidentally rather, pollen from the stamens of one flower to the pistil of another.

FIG. 75. Butterflies and Bumblebees Like Clover Blossoms.

Plants have developed special structures, that aid materially in cross-pollination or make self-pollination impossible.

In the common sage the anthers are hinged at the middle to their filaments, and they mature before the stigma of the same flower. A bee trying to get at the nectar in the bottom of the flower strikes the lower part of the lever anther, which turns down and strikes the bee on the back, dusting it with pollen. The dusted bee then goes to another, perhaps older flower, with withered anthers but mature and opened stigma. The style in this flower is elongated, and the stigma held right

in the way of the bee which, in attempting to go past it, brushes off some pollen against the stigma.

When a bee alights on a sweet-pea flower it rests upon the wings and keel of the flower. The weight of the bee depresses these parts, which makes the stamens and style protrude through the end of the keel. This dusts the bee with

FIG. 76. Sphinx-moth.

pollen, and in the next flower this pollen is rubbed off on the stigma.

The primrose illustrates another device for cross-pollination. Some of the plants have flowers with short stamen and long style, and others just the reverse. Insects visiting these flowers transfer the pollen of the short stamen to the short style, and from the long stamen to the long style.

The lady's-slipper is a remarkable case. The bee enters by the incurving fold of the slipper. It cannot get out again

this way, however, but must leave the flower by one of two openings near its base. In doing so it rubs against a pollen-mass, which adheres to the insect's head or shoulder. When the bee tries to get out of another flower it rubs off the pollen-mass against the stigma, and in passing on takes along another pollen mass.

In many plants self-pollination is impossible, because the stamens and pistils are in different flowers. This is the case in the begonia, in the pumpkin, and many others.

Some plants are so dependent upon insects that but for them little or no seed would be formed. The common red clover, generally pollinated by bumblebees, produces seed only in small quantity if bumblebees are not about.

Parasitic Insects

Insects have many enemies and endure many hardships. The rain and the cold kill great numbers, and moles, shrews, bats, birds, frogs, toads, fish, etc. eat them. They are also subject to disease. Attempts have been made to spread contagion artificially among chinch-bugs and locusts, in order to destroy them. Flies die from a fungous disease. Insects prey upon each other. There are predaceous insects like the dragon-fly, tiger-beetle, etc., that kill and eat many of their fellows. Some insects destroy the lives of others by parasitically feeding upon or within them. All these checks upon multiplication are welcomed by man, providing they do not affect our beneficial insects. And we consider insects useful if they help us to get rid of the more harmful kinds.

The little polka-dotted red or orange Ladybug is a very useful beetle because it destroys great numbers of plant-lice, scale insects, etc. It should be protected. One kind of lady-

bug has been introduced into this country to help fight the scale and other insects which injure the fruit trees in California.

The injurious cotton-boll weevil has an enemy in the form of a certain species of ant.

Ichneumon-flies are interesting and beneficial insects. One form, the Thalessa, is a wasp-like insect, with a long slender body terminating in a very long thread-like ovipositor. By means of this instrument the female penetrates the bark of trees to the burrows of larvæ of the borers, and inserts her eggs in the bodies of these insects. The eggs hatch out and the grubs then feed upon the vitals of the host. In time the host succumbs. By this time the ichneumon grubs are ready to leave or to pupate. They burrow their way out of the host and pupate in the borers' burrow or tunnel, from which they emerge as winged insects. There are other kinds of ichneumons and other parasitic insects, particularly the Microgasters and Chalcis-flies and the Tachinid and Syrphus Flies, which attack caterpillars and other insects by laying their eggs in them to hatch out there and destroy them. The large Grape, Cecropia, Cynthia, etc., Caterpillars are often thus affected. Generally before the caterpillar reaches the pupal stage its parasites have run their larval course and, boring their way out through the walls of the sick caterpillar, spin their cocoons on its surface. The caterpillar quickly dies from the effects. It is interesting to note that the mother insect seems to use judgment in laying her eggs in other insects. If the host is small only one or a few eggs are laid in it. If large then a greater number, according to the abundance of the food supply. The affected caterpillars sometimes manage to live until they form the chrys-

alis, but they do not develop into butterflies or moths. The caterpillars attacked by parasites generally are restless, and show evidence of discomfort or pain. Often we find chrysalises, of the cabbage caterpillar, for example, with little holes, or punctures, in the case. They had parasites which came out through the holes. By these parasitic insects many injurious caterpillars are kept more or less in check.

Biological relations in nature are very complex. Each species must have nourishment, and this must constitute some other form of life, plant, or animal. In this way a fair balance is kept between the different kinds of life, one acting as a check upon the other. Mr. F. S. Mathews[1] quotes an appropriate doggerel to express this idea in another way:

> Little fleas have lesser fleas upon their backs to bite 'em,
> And these fleas have lesser fleas *ad infinitum*.
> Great fleas have greater fleas upon their backs to go on,
> And these fleas have greater fleas, and greater fleas, and so on.

Some Good or Harmless Insects

The honey-bee has already been described on page 205. Another domesticated insect, which is always interesting to children, is the Silk-moth. Silk-worms are reared artificially in a number of countries of Europe and Asia. The caterpillars are carefully tended and fed with mulberry leaves, and when they have reached the pupa stage, they spin around them a cocoon of a fine strong fibre, the silk which we use.

The fibre is derived from a gland in the body of the caterpillar, and issues from a spinneret on the lower side near the mouth as a liquid, which, however, solidifies in the air.

In the silk culture the cocoons are collected and the pupæ

[1] "Familiar Life in Field and Forest."

killed. The silk fibre is then unravelled and reeled into skeins, is spun into thread, then woven into cloth, and dyed or left natural.

This is a profitable subject for a nature lesson in connection with geography, when a silk-producing country is being studied. The lesson should be well illustrated with silk, cloth, thread, floss, pictures of the insect in different stages, and if possible some real cocoons.

Professor V. L. Kellogg, of Leland Stanford University, California, kindly agrees to send any teacher several dozen eggs of the Chinese Silk-moth for five cents. Children would be delighted to watch the development of the eggs and caterpillars. Eggs and cocoons may also be got from Mrs. Carrie Williams, San Diego, Cal., and from the Division of Entomology, United States Department of Agriculture, Washington.

Though the Ants may be sometimes troublesome in pantries and on the lawns, on the whole we generally consider them with a kindly interest. They have a community life similar to that of the bees. This and their intelligent ways of managing the colony, and many other interesting habits make ants an entertaining subject of study.

There are queens, males, and workers in the colony. Ants, like the bees, belong to the *Hymenoptera* (Membrane-winged). The workers have no wings, but the queens and males do. In the summer one may often see the winged queens and males swarming, generally about some tree, during the mating. After the mating the queen returns to the nest. Often her wings are then pulled off by the workers or herself, and she settles down to the business of laying eggs to increase the population of the colony. The winged forms may often be seen in disturbing some ant-hill, or overturning a stone under

which there is a colony, or opening the home of a colony that lives in a rotten log.

The homes of ants do not show the skill of architecture that is manifested by the bees. The earth dwellers generally have labyrinthine subterranean galleries, tunnels, and chambers, and those that live in logs sometimes completely honeycomb the wood.

When an ant-hill is broken open there is generally great excitement among the inhabitants. They rush about with small white bodies in their mouths, either eggs or cocoons, which they are endeavoring to carry to a place of safety.

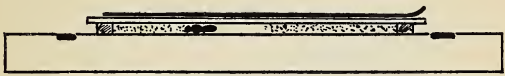


Fig. 77. Ant Cage.

The eggs are very small, and are not the larger white bodies generally considered eggs. These are the cocoons.

The ways of ants may be very well studied in the schoolroom by placing a lot of ants and cocoons in a dish covered with a pane of glass. If the dish is not opaque wrap it in opaque paper. Lay a flat stone, a chip, or piece of bark, slightly raised, in the dish. The ants will soon collect the cocoons and themselves under the cover, and this may be removed occasionally and the progress of the colony observed. Feed the ants with sweetened water, succulent herbage and fruit. They also like caterpillars and meat.

A convenient ant cage or formicarium has been devised by Professor Comstock, which can easily be made and modified to suit convenience. It is made by taking a plank about 16 x 18 inches, cutting a deep trench near its edge, and making a moat of this by filling it with water. This moat

is to keep the ants in the cage. Place a shallow tin tray about 10 x 10 inches on the plank. Lay a sheet of glass in the tray. Then lay thin strips of wood or glass, a little thicker than the height of an ant, around the edge of the sheet of glass. Fill the inner space with fine earth. Then lay on top of this another sheet of glass like the lower, but with one corner cut off (about two inches on each side of the corner). This opening will allow an entrance to the earth within. Then lay a corresponding piece of heavy paper or, better, tin on this. Now get your ants, being sure to get also a queen, and cocoons, and some of the earth in which the nest was found. (The queen is larger than the rest, has a thicker abdomen, and usually wings.) Place these on top of the cage, removing the excess of earth. Leave alone a day or so, and the ants will have taken up quarters within the cage. By removing the cover, the galleries, rooms, young and old ants, cocoons and eggs may be seen. Do not let the nest get too dry. Pour a little water into the tray occasionally. Such a colony may be kept a long time if properly cared for.

Crickets also belong to the interesting and harmless, rather than to the injurious, class. Occasionally, when they collect in too great numbers in a house, they become annoying, and they may sometimes do a little harm to field crops. They are especially abundant in the latter part of the summer, when they may be found sunning themselves in the meadows and along the roadsides. Here also they are laying their eggs. Crickets are preëminently autumn insects, and during the day and the night the rather pleasant sound of their chirping may be heard. We speak of the cheerful crickets. Perhaps it is their chirping that makes us feel so. Crickets have always had a popular place in literature.

Crickets are cousins to the locusts or grasshoppers. Generally they are black. They resemble locusts somewhat in shape, but their wings are much shorter, the hind pair being often useless. They do not fly much, but depend on jumping and running for escape, and they are very nimble.

The males do the chirping by rubbing the edge of one front wing over the outer surface of the other. On each outer wing there is a ridge with tooth-like projections. By drawing the other wing over this rough ridge it is made to vibrate, much as we make a sound by drawing a card over a comb. This chirping is the love song of the male. Presumably there are female ears to hear it. Cricket's ears are not on their heads, but on the first joint of their forelegs above the foot. Here will be seen a little oval pit with a membrane stretched across. The spot is somewhat transparent and is easily found. Catch some crickets and put them in a cage or jar; you will probably hear them chirp, and by approaching quietly you may see how they do it. They make good school-room pets.

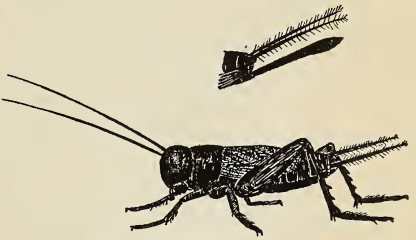


Fig. 78. Male Cricket Below. Female Egg Placer Above.

The female cricket has a long slender organ at the end of her abdomen which is the ovipositor or egg placer. By means of it she can penetrate the earth and lay her eggs in the soil.

Another cousin to the locust is named the Green Grass-

hopper to distinguish it from the common grasshopper or locust. This resembles a cricket or a locust in general structure. It is found in grass and in the trees, hence its color for the sake of protection is green. The Meadow Grasshopper is a common kind. It is long and slender, with wings that extend beyond its body. It has very long antennæ, and a pair of very long jumping legs. This kind is seen in the tall grass of meadows, clinging to the blades and stalks. The male makes a chirping noise by rubbing the wing covers upon each other.

FIG. 79. Sounding Wing of Cricket.

The Katydid is another kind of grasshopper, that lives in the trees, and in the quiet watches of the night argues continuously, "Katy did," "Katy didn't." The sound is made as by the other grasshoppers. The Katydid looks somewhat like a cricket with long, broad wings.

On hot summer days we often hear a shrill, trilling sound emanating from the tall trees, a sound that resembles a miniature snare-drum or a miniature alarm-clock going off and gradually running down. This sound is made by the Dog-day Harvest-fly or Two-year Cicada, or perhaps by the Seventeen-year Cicada. These insects are sometimes, but erroneously, called the "Locust." The cicada is related to the Bugs (*Hemiptera*).

FIG. 80. The Ear of a Cricket on the Front Leg.
(Photomicrograph.)

It is a rather large insect, nearly two inches in length, with clear, strongly veined wings. It has a broad, triangular head,

terminated by a stout, sharp beak, which is generally folded under the head. The compound eyes are prominent, as are also the three ocelli.

The song of the cicada is produced in a pair of elaborate drum-like organs on the under side of the abdomen. Turn the insect over and a pair of circular covers will be seen just behind the hind legs. Lift these up and you will see a cavity under each. Across this cavity are stretched membranes which are made to vibrate by the rapid contraction and relaxation of attached muscles. The females have no such sounding apparatus and are therefore silent.

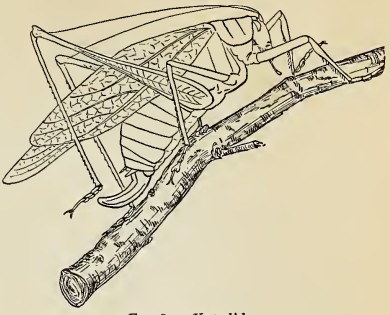


FIG. 81. Katydid.

FIG. 82. Cicada.

If cicadas are found that have dropped from the trees they should be brought to the school alive and kept in cages. Feed them on succulent leaves.

The development of the so-called seventeen-year cicada is interesting because the larvæ grow very slowly, taking from 13 to 17 years to mature. They live in the ground, feeding upon tender roots. The two-year cicada develops in two or three years.

Cicadas have been famed in poetry ever since the times of Homer.

Butterflies and Moths

The most beautiful of the insects are the Butterflies. These airy, flitting, little beings always attract and cheer the eye. They frequent the flower gardens, the roadside flowers, and the flowers of the meadows and forest borders.

The Cabbage Butterfly is the most common of our butterflies. As its caterpillar eats cabbage and related plants and also the nasturtium, it is considered a noxious insect. It is seen in every vegetable garden and in fields and meadows. The male has one black spot on each fore wing; the female, two.

Fig. 83. Moulted Skin of Cicada.

A common butterfly similar to the preceding, only yellow, is the Clouded Sulphur or Clover Butterfly. This form is seen often in clover fields where its larva feeds on the clover. The wings are black bordered. The fore wings have each a black, the hind an orange, spot. The female is sometimes white.

The Mourning Cloak is a rather common butterfly with dark-brown, yellow-bordered wings. Its black spiny caterpillars feed upon the leaves of willow and poplar. Some of these butterflies pass the winter in the adult stage, and occasionally on very mild days in winter or early spring they may be seen flying about.

The Swallowtails, of which there are several species, are among the handsomest and largest. They are called thus because the hind wings are drawn out into tapering ends. They frequently visit flower gardens. The Red Admiral is

a medium sized butterfly with purplish wings, the front pair bearing a conspicuous orange or red band across their surface. The larva feeds upon hop and nettle.

Fig. 84. Monarch Butterfly Sipping Clover Nectar.

In the latter part of the summer the Painted Beauty is commonly found on the asters and other fall flowers. It is a very nimble and active butterfly. The upper surface of the wings is blackish, with orange and white spots. The under side of the wings is the finest, being marbled with brown, gray, and white, with rose-colored spots on the front pair, and two eye-like spots on the hind wings. It is one of the daintiest and most beautiful of our butterflies. It measures about two inches across its wing-tips. This butterfly, like some others, has the interesting habit of playing dead when caught, coming to life and making off quickly when there is a chance to escape.

Fig. 85. Comma Butterfly Just Out of Chrysalis.

Another common butterfly is the Violet Tip, so called from the violet border of its brown wings. It is also called the Comma Butterfly, because of a curved, silvery spot on the under side of the hind wing. A very handsome and the largest of our butterflies is the common Milkweed or Monarch Butterfly. Its

larva, which is a large, fleshy, yellow and black striped caterpillar, feeds upon the leaves of the milkweed, and forms a beautiful green and gold chrysalis.

The adult has broad, brown wings, banded or nerved with black, with several rows of white spots along the border. An interesting thing about this species is that toward the close of summer it migrates southward in vast swarms. I have seen the sky full of these butterflies flying and drifting with

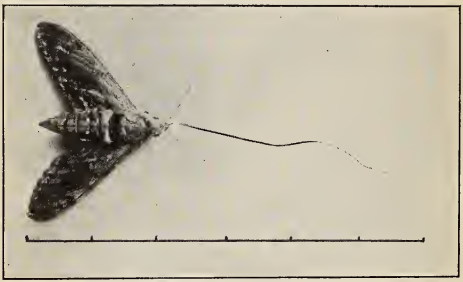


FIG. 86. Sphinx-moth.
(Note long proboscis. Scale in inches.)

the wind on their way South. Sometimes they will settle for the night in the trees of the forest, when it is an easy matter to collect them by the hundred.

A butterfly which, by most people not especially acquainted with it, is taken for the monarch is the somewhat smaller Viceroy. This butterfly illustrates the wonderful mimicry that some insects and other animals are capable of. The monarch butterfly is not eaten by birds, probably because of a disagreeable odor and taste. The group to which the viceroy belongs are generally purple and white, and are liked by birds, but the viceroy by putting on a "lion's skin,"

resembling the unpalatable monarch, escapes harm from the birds. This is a remarkable case of adaptation for protection. The viceroy may, however, be distinguished from the monarch by the fact that it has a black band across the hind wings, and some minor differences.

The caterpillar feeds upon willow leaves, and forms a cocoon in a curled-up leaf.

Many of the Moths are beautiful. Many, though inconspicuous when at rest with folded wings, have bright colors on their under wings and back.

The common Tomato-worm, feeding on the tomato plant, is a large, green caterpillar, with a sort of tail-like projection near the hind end, oblique markings upon its segments, and a line down its back. The green color and the markings very nicely imitate a curled-up leaf, with its veins and midrib. The caterpillar is about three inches long. When ready to pupate it burrows into the ground and forms a chrysalis, but no cocoon. There is a peculiar, slender handle to the chrysalis, which is a special case for the very long tongue or proboscis of the coming moth. In the spring the pupa wriggles to the surface, and the moth emerges. This is a beautiful insect with large, gray marbled wings, five yellow spots on each side of the back of the abdomen, and large antennæ. The tongue is unusually long. It is generally kept curled up like a watch-spring under the head, but when in use in sipping nectar it is straightened out and then measures nearly four inches in length. If such a moth is caught and killed, the tongue may be straightened out with a pin or forceps, the end gently clamped, and the moth suspended from this and allowed to dry.

Such a mount of a moth with extended tongue is very in-

structive, and shows well how the insect is adapted for sucking nectar from deep-tubed flowers, such as the honeysuckle, lily, etc. The moth may be seen flying about the flower beds toward dusk. Because the wings are kept in a state of rapid vibration it is called the Humming-bird Moth.

Fig. 87. Caterpillar of Cecropia-moth.

It is about as large as a humming-bird. It is also called the Hawk-moth. It belongs to the group of moths known as Sphinx-moths. Other common moths of this group are the Grape Vine Caterpillar, the White-lined Sphinx-moth, and the Bumblebee-hawk Moths, also called Clear Wings from the transparency of their wings.

Another remarkable family of moths is that of the Giant Silk-worm. This includes the Cecropia, Promethea, Io, and Luna Moths, all of which are very large and beautiful.

The Cecropia-moth is the largest of our moths, measuring sometimes over six inches from tip to tip of wing. Its general color is dusky brown, with blending borders and spots of black, red, and white. The body of the moth is very thick and plump, and it has a pair of large feath-

ered antennæ. The legs are covered with hairs, and the body also is hair-covered, especially the chest. The abdomen is marked with white bands. The moth is nocturnal. Its caterpillar is a large, fleshy creature of a dull green color, with rows of blue tubercles at the sides, and yellow tubercles on the back. It is about three inches in length. The caterpillar feeds upon butternut, walnut, cherry, willow, and many other trees, and spins a large silken cocoon on the twigs of the food tree. These cocoons are very conspicuous in the winter on the bare trees and may then be collected. They are made of a good quality of silk and are double walled. At the top is left a loosely covered opening, through which the moth comes out in May or June.

Children should be instructed to bring in such cocoons, which may then be hung up in the school-room. The emergence of the moths may be seen in the spring, and will always cause a mild excitement. It is very interesting to see the moth coming out with soft, crumpled wings, and then proceed to inflate them.

The Io or Bull's-eye Moth is a smaller species, called by these names because of a large eye-like spot on the hind wing. The female is brown, the male yellow, with shadings of purple, black, and red.

The Promethea-moth is also a common species. It somewhat resembles the Cecropia, but is smaller, being about four inches across from tip to tip. Unlike its cousins it is a day flier. The female is reddish brown, with a wavy line of white across both pairs of wings. There is a conspicuous eye spot in the outer corner of the front wings. The male is black. The wavy white line so noticeable in the female is faint, but the eye spots are there. This moth has a very

short, useless tongue. It is said that it does not eat in the adult stage. Its cocoon is found on fruit, nut, and other trees where it has lived as a caterpillar. The cocoon is spun inside of a rolled-up leaf. The caterpillar seems to know that the

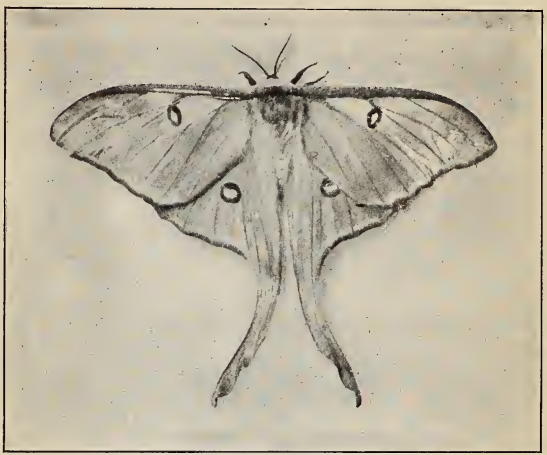


FIG. 88. Luna-moth.
(General color apple-green.)

leaf may drop off in the fall, so it fastens the petiole firmly to the twig with silk fibres.

One of the finest moths is the Luna-moth, whose caterpillar feeds upon various trees, such as the walnut and the hickory. The caterpillar is pale green, with a pearly head, yellow lines transversely between each two segments of the abdomen, and a yellow line along each side of the body. The adult moth is of an apple-green color, with a border of brownish purple on the wings. Each wing has an eye spot with a transparent

centre. The hind wings are drawn out into curving swallow-tails. It is a nocturnal insect, and is often attracted by electric lights.

Protective Devices

We have seen that insects have many enemies. Some, however, are especially adapted to escape them. A few, like the flies and dragon-flies, depend upon their fleetness of wing. Others, like the water-spiders and water-beetles, escape by diving down into the water, carrying with them a globule of air to breathe. Locusts and crickets are good jumpers. Wasps and bees have a good weapon of defence that we have learned to respect. Beetles have, in addition to their naturally strong chitinous skin, a pair of hard wing-covers that serve as a shield.

But more interesting are the modes of concealment practised by many insects. The one that escapes observation the best is the one that will escape being eaten by birds and other creatures, or attacked by parasites. Very many insects imitate not only the colors of their background, but even the shape of leaves, sticks, and insects that are not attacked. Plant-lice, leaf-hoppers, lace-wings, grasshoppers, and many caterpillars have the same color as the leaves upon which they live. Other caterpillars, moths, butterflies, beetles, and bugs mimic the grays, blacks, and browns of the twigs and bark of the trees or the earth. So effective is this mode of concealment that they are generally not seen unless they move, or happen to be on a differently colored background from that upon which they generally stay.

The Walking-sticks found upon oak and other trees are beautiful examples of protective mimicry. The long, slender,

jointed body is gray or brown or green to match the twigs of the tree, and the long, thin body and legs are like thin, green branches.

Fig. 89. Walking-stick.

Many of the Canker-worms or Inch-worms resemble twigs very closely, and when disturbed assume motionless, twig-like attitudes.

One of the most striking illustrations of protective coloration is the Kallima, a South American butterfly, which has blue and orange colors on the upper side of its wings. This butterfly, when resting, assumes a leaf-like attitude, and the wings are closed, exposing only the leaf-colored under side. There are even lines that mimic the venation of a leaf, so as to make the illusion more complete.

A number of our native butterflies, with conspicuous upper wing-surfaces, conceal themselves on the leaves and bark of a tree, the under side of the closed wings mimicking the color of these surfaces. Moths also are protectively colored, usually on the upper surface of the first pair of wings.

In the description of the viceroy butterfly, reference was made to the fact that it put on, as it were, the livery of another butterfly, which for some reason seems to be immune to the attacks of birds, namely, the Monarch. Many other such cases of mimicry may be mentioned.

One day I found on some goldenrods what I took to be a new kind of bee. It was a beautiful, gold-banded insect, and I wanted it for my collection. So I captured several in my cyanide bottle, taking good care not to be stung. Later, on closer examination, I found that this was not a bee at all, but a harmless fly which had put on the dress of a bee, probably to make other creatures think that it, like the bees, carried a dangerous, concealed weapon. It was one of the Bee-flies.

FIG. 90. Protective Coloration of a Moth.

It is not intended to intimate here that these protective colors and forms were brought about consciously by the insects themselves, as if they made an effort to develop along these lines. It is certainly a fact, however, that they avail themselves of these protective devices.

How these advantageous characteristics arose is difficult to say. They did arise, however, in the course of evolution in each case, and then the law of natural selection operated and, in the struggle for existence, the forms not so well adapted disappeared and the fittest survived. Those that were protectively colored or shaped to resemble twigs, leaves, dangerous creatures, etc., were the ones most likely to survive.

CHAPTER XV

SOME LOWER ANIMALS

A FEW of the lower animals should receive some attention besides those already discussed. Spiders, crayfish, lobsters, crabs, clams, oysters, snails, starfish, coral, sponges, and other related forms make very interesting nature-study material.

Most people probably think of Spiders as insects. Pupils should be taught the chief distinctions between these two classes. Spiders have eight legs, and their bodies are divided into only two principal parts. The head and chest are not distinct from each other, but the abdomen is marked off from them. Spiders do not have compound eyes, but a variable number of simple eyes. Furthermore, they have no wings. Otherwise they closely resemble insects. Spiders have good mouth-parts adapted for catching and eating insects. The jaws or mandibles are especially large and terminate in sharp fangs, through which a poison can be ejected into the victim which kills or paralyzes it. This poison, however, is not powerful enough to produce painful or dangerous results in man, except in the case of the larger ground spiders, such as the tarantulas, whose poisonous bite is painful, but not, as is usually believed, fatal to man. The spider has a pair of jointed palpi or feelers, which often resemble another pair of legs.

Spiders make good school-room studies. Have the children

bring to school different kinds of spiders, and put them into jars or cages. Feed them and observe their interesting habits. Spiders may be found in attics, cellars, sheds, and barns, on garden flowers, on fences and old walls, under stones and boards, under the bark of decaying logs, etc. In these places will also be found small, round masses of eggs wrapped in silk cocoons. These also should be gathered and allowed to hatch out in the school.

There are many kinds of spiders, and each has its peculiar ways of catching prey, building a home, etc. Under stones, logs, and bark, are found ground and running spiders, which are very nimble and catch their prey by running. On old fences and walls are found spiders that lurk for insects, and when these come near enough they suddenly pounce upon them. These are the jumping spiders. In the heart of many garden flowers there lie in wait certain spiders that assume the color of the flower, and catch unsuspecting butterflies and other insects. These, from their peculiar shape and the habit of running sideways and backwards, are called crab spiders. They do not spin webs to catch their prey.

Fig. 91. An Orb Weaver.

But there is another class of spiders that spin snares with which to entrap flies and other insects. These webs are of different degrees of beauty and perfection of construction. The housewife is worried by the appearance of cobwebs on the ceilings and in the corners of her rooms. This is a web spun by a spider. Cobwebs have no definite shape or plan. They are simply loose or dense, tangled masses of fibres spread out

in sheets. The funnel spiders' webs are somewhat more perfect. In the summer and early fall we often see the lawns covered with dense masses of cobwebs. These are sheets of web suspended from the grass, and centering about a funnel-shaped hole of silk, at the bottom of which the spider lives. When a fly falls into the web the spider rushes out to seize it.

Fig. 92. Funnel web Spider.

The most beautiful webs are made by the garden or orb spiders. These webs are frequently seen hung nearly vertically among the branches of garden plants, the angles of fences, open windows and doorways, etc. It would pay to make a study of the construction of such a web, especially if one is so fortunate as to see the spider making it. Note the supporting threads, the radii or spokes of the wheel, and the spiral thread. Note also that only the spiral thread is sticky. Examine closely and see the minute globules of viscid fluid that cover this spiral thread. Some species of spiders rest at the centre of the web, others lie concealed in some leaf or other nook near the web. A thread running from the web is held by the spider, which can at once tell when an insect flies into the net. Take the class out into the gardens or fields and study some of these webs. Throw some insects into the net and see what the spider does with them. There is a curious little spider, often seen in the fall, which is known as the balloon spider. It causes the air to be filled with delicate gossamers or threads of silk. It is a small,

black spider, that may be seen running on the ground, on the fences, or upon plants. It has a way of thrusting up the abdomen and ejecting a thread of silk, which is carried along by the wind. As the wind takes the thread, the spider spins

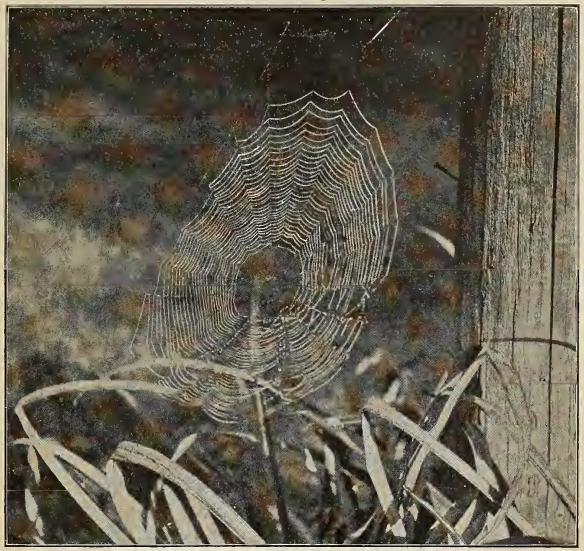


Fig. 93. Dewy Web of an Orb Spider.
(The spider lives under one of the lily leaves.)

out more, and, when the thread is several feet in length, the spider makes a little leap and sails off on its silken balloon. Pick up some of these spiders, and on letting them crawl up to the end of a pencil or the finger you may observe this performance.

At the rear of the abdomen is the spinneret, from which

the silk threads issue. This consists of a number of little projections covered with minute, tubular hairs, through which the threads come. The silk is at first liquid, but quickly hardens in the air. The different strands are pressed and twisted together into a strong thread. The spider uses its hind feet in arranging, guiding, and fastening its silk.

Fig. 94. Spinneret.

Shake a spider from its web. Notice that it is still attached to the web by a fine thread upon which it again climbs back.

Spiders are useful creatures and destroy many insects. Out of doors they ought to be protected rather than killed. Try to counteract the prevailing prejudice against them.

Related to spiders are the Daddy-long-legs, or Harvestmen, which also are useful in destroying mosquitoes and other insects.

Centipedes and Millipedes possess the segmental character of the body, the jointed legs, and the biting mouth-parts of insects, yet are very different. They are found under boards, logs, and stones. Centipedes are flat, worm-like animals, with a pair of legs to each joint of the body. They are carnivorous, living on other insects, worms, etc., which they catch. The first pair of feet are modified into poison fangs. In tropical countries there are large centipedes whose bite is dangerous to man. Similar to the last is the millipede, or

thousand-legs. This, however, has two pairs of legs upon each segment. It feeds chiefly upon decaying vegetable matter. It is more cylindrical in shape than the centipede, and is harmless.

In the cellar among the vegetables, under boards and stones, we often find little flattened, jointed, insect-like animals which have legs on all the body segments, and which have the habit of curling up into a rounded mass when disturbed. These are called Pill-bugs, or Wood-lice, but are related more closely to the crayfish than to insects.

It is well also to call attention to the many minute forms of animals that swarm in the stagnant waters of pools and sluggish streams, and in lakes. A jar containing such water will show to the naked eye even these animalcula swimming about, some barely visible, others large enough to be plainly seen. Many of these consist of water-fleas and copepods, animals related to the crayfish. With a compound microscope a drop of water is seen to teem with animalcula. Let the children know that these small animals are very important, in that they form the food of many larger aquatic animals. Fish are very fond of them. Put some minnows in a jar with these animalcula, and see how eagerly they feed upon them.

The seashore is a rich field for the naturalist, and teachers on the coast should make the most of their opportunity by studying the plants and animals which the waves throw upon the sands. In inland waters, though the life is not so varied, yet there are some animals that we should study.

The Crayfish is very common in lakes and streams. Its structure should be compared with that of the insects. The articulated body and appendages should be noted. Study the eyes, mouth-parts, the large claws and feet, the swim-

merets and the tail. What does the crayfish do with its claws? How does it crawl? Observe the way it swims. Note the hard shell. Crayfish grow by moulting their shells like insects. We often find the little shafts or tunnels of crayfish in wet meadows. They make these in digging down for water or wet soil. Along rivers that are enclosed by dikes or levees, crayfish sometimes cause great harm by boring through the earth wall and thus beginning a great crevasse or break that may cause much damage. Crayfish are scavengers and live upon dead animals, fish, etc. The protective coloration of the crayfish should be referred to. Correct the misuse of the word "crab" for crayfish.

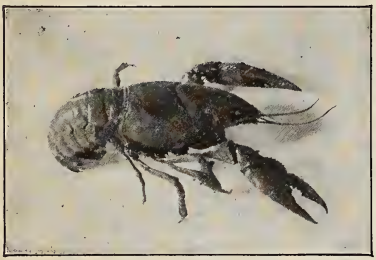


FIG. 95. A Crayfish.

The Lobster and the Crab should be compared with the crayfish as to structure. They are salt-water animals, and are best studied at the seashore, where their life habits can be observed. Lobsters are very much like large crayfish in structure. Those seen in the markets are generally red, but this is not their natural color, which is much like that of the crayfish. The redness is due to the fact that the lobster has been boiled. Crabs differ very greatly from the crayfish in shape, and yet their relationship can be readily recognized. Their bodies are short and broad, and their abdomen is always bent under the thorax. They crawl

backwards and sideways as well as forward. Vast numbers of lobsters and crabs are caught and eaten on the sea-coasts.

Mollusks constitute another type of animal life. Clams, oysters, and snails all are interesting creatures to study. These animals as a rule have a limy shell which is secreted by the skin.

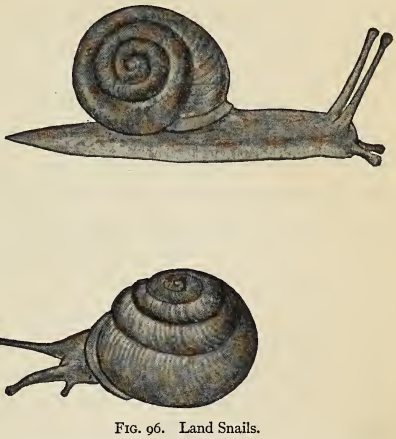


Fig. 96. Land Snails.

Snails are to be found in ponds and streams, on sticks and stones, and on water plants. Some kinds are found on land, in gardens, on bark, and old logs. Some snails have a shell of a cornucopia shape, and others have a flat spiral. Some, like the slugs, have no regular shell, but only a small, scaly mantle on the back. The shell is increased at the free edge by the addition of new layers.

Many snails breathe air in the water by means of gills. Among the aquatic snails the kinds that can close the opening of the shell with a sort of flap or door are gill-breathers. Other aquatic snails are lung-breathers, and must come to the surface of the water periodically for more air. Land snails also have simple lungs.

When a snail is "out of its shell" there will be seen a long,

fleshy portion, upon which the creature rests and with which it crawls. This is the foot. At the front end are to be seen some horn-like projections called antennæ or feelers. Land snails have four such, the second pair larger and bearing the eyes. If the animal is touched on the antennæ it quickly retracts them, turning them inward, as we turn a glove finger inside out. Water snails have only two feelers, and the eyes are at their base. As land snails crawl over the ground and plants they leave a track of slime.

Snails feed upon algæ and other plants. Some of the land snails do considerable harm to the vegetables in gardens. Watch a snail as it moves along on the glass of an aquarium. On the under side near the front will be seen an opening, the mouth. This is provided with a hard upper lip, and a rough, rasp-like "tongue," with which the snail scrapes and eats.

The Fresh-water Clam or Mussel is common on the sandy flats of lakes and rivers. This shell animal burrows, or rather ploughs, in the surface of the sand and makes long furrows. It moves by means of a strong, fleshy foot.

Clams breathe by means of gills within the shell. Water is kept constantly in circulation through the gills. This circulation may be nicely shown by the following experiment on a clam in an aquarium. Be careful not to disturb the animal lest it close its shell. With a long pipette or fountain-pen filler carefully drop some indigo, carmine, or ink solution just behind the shell, at the end opposite to the foot, near the sand. It will be seen that the colored liquid is drawn in, and then later ejected from another part of the shell a little higher than where it entered.

The shell is an interesting structure. It has a hinge of elastic ligament, which naturally tends to hold it slightly

open. The animal, however, has strong muscles on the inside with which it can hold the shell tightly shut.

The shell is increased by the addition of concentric layers, which can be seen on the outside. Many mussels have a beautiful, iridescent lining to the shell—the mother-of-pearl. This is used in making buttons and ornaments. On the Mississippi and its tributaries there flourishes a large industry of collecting clams for their mother-of-pearl. In some clams and other mussels true pearls are formed as an unnatural growth between the shell and the fleshy mantle lining it. The nucleus of a pearl is generally some foreign body, such as a grain of sand. Let the children read about the Pearl Oyster of the Indian Ocean. Fine pearls are often found in fresh-water mussels.

In comparison with these animals the common Oyster should be studied. Get unopened oysters and make a general comparison of structure with that of the clam.

Many creatures are called "worms" which are not strictly so at all, but the Earth-worm is a true worm. A brief study of the segmental body, the bristle feet, the life habits, and the uses of this creature should be made. Worms, unlike the worm-like caterpillars and grubs of insects, do not change into some other form. For comparison a study may be made of the Leech, or Bloodsucker, another worm that is abundant in sluggish brooks, in ponds and lakes.

The Starfish and Sea-urchins, found on the seacoasts are types of animals built upon the radial plan. The mouth is at the centre, on the under side, and the various other organs of the body radiate from this centre. Starfish have a number of arms, on the underside of which are little, sucker-like feet, with which the animal moves. Sea-urchins have a similar

structure. Both are protected with a calcareous shell provided with knobs or spines. When the animal is killed the fleshy parts decay, leaving the shell, and this is all that we see in the specimens often found in the homes as curios.

The Coral Polyp, being of so much importance in geography and geology, should not be omitted. It is one of the lower animals that in its fixed growth is almost plant-like. Essentially this animal is a little fleshy sac, with an orifice or mouth at the top, which is surrounded by a number of arms or tentacles. These arms wave about in the water and draw minute animals into the mouth. The coral polyp forms a hard deposit of lime carbonate in the lower part of its body-wall, and this is what remains after the death of the creature. It is this part which is used for ornaments, and which builds up great coral reefs and islands in the sea. Many large rock areas in the earth are made of coral limestone deposited in some former age. The branching of corals is due to the fact that these animals have the power of producing buds on their sides, which develop into other polyps and remain connected with the parent animal.

Show pictures of the coral polyp, diagrams to show its structure, and pieces of coral skeleton of various kinds. The coral polyp is appropriately studied in connection with Florida, or the islands of Polynesia, in geography.

In our fresh-water lakes and streams we have an animal that resembles the coral in many respects, except that it forms no skeleton. This is the Hydra, which may often be seen in aquaria attached to the sides. If one of these can be found it should be used to illustrate the general appearance and habits of the coral.

Another very low animal, also of fixed location, is the

Sponge. A simple study may be made of it. Note how it encrusts plants or rocks, the color, and the rough feeling due to minute needles of silica. The horny or leathery skeleton of the bath sponge is the chief thing to note. The method of fishing for sponges and their preparation are also of interest.

CHAPTER XVI

THE SCHOOL GARDEN

CHILDREN'S gardens are an important aid in education, not only because of the practical, but also for the culture value of such study. Gardens have been maintained for a number of years in connection with many schools in this country. At first they were mainly for the decoration of school-grounds, but they have now been found to be a useful educational material. Industrial schools, such as our agricultural schools, the schools for the indigent, for the negro and the Indian, etc., soon put the garden idea to more practical uses, both to train the pupils mentally and morally, and to teach them something that would help them to earn their livelihood. The primary schools are beginning to work along the same line, but the custom is not as prevalent as it should be. In Europe school gardens are an established institution. At first they were maintained to furnish the teachers with a part of their support, but long ago they broadened out into real educational lines.

The school garden should be a sort of outdoor laboratory, a place for the outdoor study of growing plants, soil, insects, weeds, etc., and for the application of the facts learned in indoor nature-study. The garden should supply material for such indoor lessons and for art study. It can be made one of the best means to develop in the pupils thrift and

responsibility, gentleness, and a love for the beautiful and for growing things. In many places it may be made very practical, as a means for teaching gardening, elementary agriculture, and horticulture.

Strange to say, the most successful children's gardens are to be found in the larger cities. One of the most remarkable

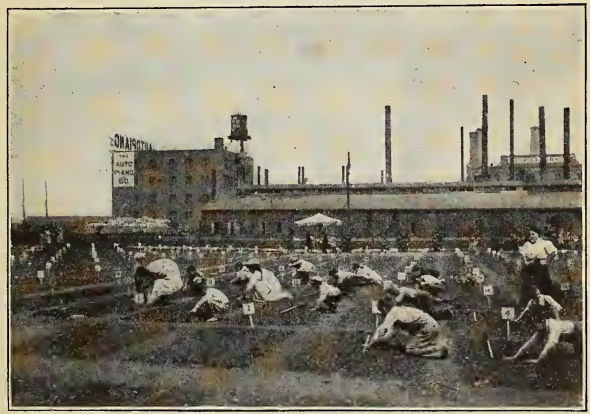


Fig. 97. Children's Farm School, DeWitt Clinton Park, New York City.

is the Children's Farm in the DeWitt Clinton Park of New York City. This is because the growing of plants is a revelation and intense joy to city-bred children, whose nature instinct has been starved. In such places the greatest enthusiasm prevails among the little gardeners.

It has been found that children's gardening is one of the very best ways of combating the evil moral effects of tenement and slum life. In such centres school and vacation gardens have worked a positive revolution in the habits and thoughts

of the children engaged in cultivation. Responsibility and care for a little plot of flowers and vegetables has the best moral influence upon such children, and develops a respect for the property rights of others. Petty thieving, and wanton destruction of flowers, trees, etc., have in numerous places been overcome by encouraging the children to cultivate gardens. The work of the Children's Farm cited above, that of the Cleveland Home Gardening Association, and of the National Cash Register Company at Dayton, Ohio, may be referred to as such instances of moral betterment. The pecuniary advantage in the crops to the poor, and the physical benefit from the open-air exercise in the garden need only be mentioned.

In cities the mere novelty and pleasure in seeing things come up and grow and blossom may be a sufficient stimulus to make the children wish to keep a garden, but in village and country schools this is not quite enough. Every boy and girl knows considerable about the cultivation of plants, and will not be interested in the simple work in the school garden, unless it can be made more useful and practical by the study of the soil, the conditions of plant life, plant behavior, relations of insects to plants, nature and effect of weeds, etc., and by using larger plots for individual beds, so that the value of the product will be an encouragement. By emphasizing the agricultural and horticultural phase of garden work, we can make it attractive and profitable to country children.

As the agricultural industry is the largest source of our national wealth, we should not neglect to train the future workers in this great occupation. Unfortunately the rapid development of manufacturing, transportation, and commerce has drawn many of our country youth to the cities;

furthermore, the proportion of immigrants that go to the fields is not as great as it used to be. As a result the cities have developed more rapidly than the country population, a result that many deplore. As a partial check to the tide from the country, it is hoped that a greater consideration of rural life, its advantages, beauty, independence, healthfulness, etc., and the study of agricultural methods from a more scientific point of view in the common school may prove beneficial. Gardening in the rural schools makes farm life more interesting, and enriches its intellectual content. Agriculture is the mainstay of civilization. If it should cease we should probably revert to savagery. When, through a series of unfavorable years, the agricultural industry fails, then all other industries are depressed. This shows how dependent we are upon nature, even in this highly civilized age. Agriculture can be successful only with a thorough knowledge and observance of the natural laws and conditions governing plant life and growth. The farmer must adapt his crops to the nature of the soil, and to the temperature and rainfall of the region, or he will meet with failure. Similarly the laws relating to animal life must be applied in the practical management of farm stock. Hence the establishment of the United States Department of Agriculture, our state agricultural schools, county industrial schools, and private schools for the same purpose. A proper study of the scientific principles that underlie farming and related industries would do much to foster an interest in this great industry, and would ennoble it. Even those who would not pursue farming as a vocation would be benefited by such education. It would help them in a practical way with making flower and vegetable gardens in cities, would increase their love for plants in gen-

eral, and would help them to appreciate in a measure what the farmer is doing for us.

Considerable of this sort of teaching can be done in every country school, and where the plan of consolidation of districts prevails, a generous provision should be made for such work by providing land for an experimental farm, and furnishing means for carrying on the work. The present tendency throughout the country to establish elementary agricultural schools indicates the demand for such training. (See also Gardening and Agriculture in the course of study under various grades.)

Our long summer vacations could be very profitably employed in the cities with outdoor schools of gardening. In this way many boys and girls could be kept off the streets, and be given healthful and moral entertainment as well as instruction.

In this connection I would urge very strongly that the children be encouraged to cultivate gardens at home. In some places this is done in correlation with the school work, especially where no space for a garden is available at the school. Many children "have to" work more or less unwillingly in the home garden. I believe that if they were given ownership rights in what they raise, their interest in the work would be greater. Let a boy have the sole care of a garden and sell his produce to the family at market rates. Or let him have the surplus not used by the family to sell to the neighbors or to the markets. Then he would not need much urging to do garden work, for it would pay. There is so much care and hard work in gardening, that it is unreasonable to expect children to keep at it spontaneously without reward or encouragement.

How to Make a School Garden

There is probably no school in which some sort of gardening cannot be done, be it nothing more than window gardening. But wherever space can be secured an outdoor garden should be attempted. Beds and borders and, best of all, a considerable area for group or individual plots should be set aside. The garden should not by any means infringe

FIG. 98. The Children's Garden.

upon the play-ground. In many places, where the school-grounds do not afford any suitable location for a garden, such may be found in vacant lots or fields nearby, which may often be had for nothing, or for a small rental.

The garden should be in a sunny location, not under trees or on the north side of a building, for plants need plenty of light.

BEDS, BORDERS, AND GROUP GARDENS: If the garden must be small, try border beds along the buildings, walks

and fences, or edge of the grounds. In such limited areas individual beds are out of the question, unless the number of children is small. Generally groups of children or classes will have to be assigned to a bed or border, to have charge of in common. These beds or borders should not be placed in the lawn, unless intended for ornamental purposes, and even then it is wiser to have them along the edges of the lawn as borders, for a neglected or withered flower-bed is an eyesore, and the green grass is much prettier. Do not place

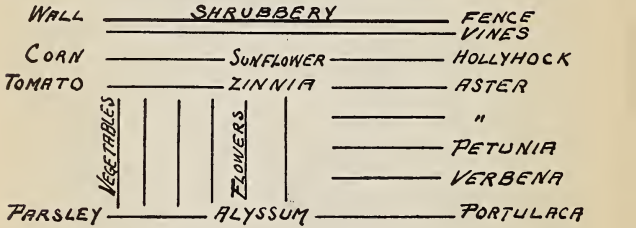


FIG. 99. Suggestions for a Border Garden Along a Wall, Fence, or Mass of Shrubbery. Plant taller plants and vines in rear, the low, trailing kinds in front. Vegetables are more easily cultivated if planted across the border. Flowers look better in rows parallel with the border.

the borders along buildings, if the rain-water would drip on them. The north side of a building or a fence will be suitable only for shade loving plants, such as ferns, many wild flowers, and some foliage plants. If, however, there is plenty of light reflected from neighboring walls, flowers may sometimes be raised, especially the kinds not requiring so much light, such as asters, pansies, forget-me-nots, violets, lilies-of-the-valley, wild flowers, etc. Have the beds and parts of the borders in charge of groups of children. These little gardens may be made much prettier than the larger garden with individual plots, and the children will take great

pride in them. But where the responsibility for the care of the beds is so distributed as it is in a large group, the teacher will have to see to it that the children do not forget to do their share of the cultivation. If the beds are near the street where they are in view, it would be better to devote them chiefly to flowers. But along back fences or other more out of the way places vegetables should also be raised, and the garden should be used more for experimenting with plant life. Such beds, though not as pretty as flower-beds, may really be better as far as the real purpose of a school garden is concerned. The little children could in such beds make miniature farms, and raise special vegetables or experimental crops. A bed or border should be set aside in some well-protected place for a tree nursery. Many useful lessons in soil preparation, planting, transplanting, tillage, etc., can be given with these little gardens. (For cultural directions and lists of plants see following pages.)

Individual Plots: In a larger garden the individual plot for children above the primary grade is the best plan for making the most of a garden. Then the responsibility for the care of a bed may be fixed and the moral benefit from the cultivation is greatest. In case of neglect by the planter the bed should be confiscated and given to some other child. In some schools beds two feet square have been allotted, but this is too small except in primary work. Larger beds make a better show and encourage the children more. They also give more of a return in flowers and produce, and may thus be of some economical value. All the pupils need not be required to take garden work. Those who have home advantages for gardening can be excused. In beginning a school garden do not attempt too much, but start out with a

few willing pupils. The work should be in charge of an experienced teacher, and in large gardens a specially trained director should be engaged.

PLOUGHING AND FERTILIZING: If the garden is large it should be ploughed; if small, spaded. Unless the spading is done by some one else than pupils, the boys of the upper grades should do it for the lower, these assisting in the finishing and lighter work. If the soil has not been tilled and is covered with sod, this should be turned down deeply. Virgin soil will not need fertilizing for several years, but old and worn out soils should be enriched. The character of the soil must be taken into account. Very light and sandy soil needs manuring especially, both for fertilizing and to form a humus to hold the moisture better. Well-rotted barn-yard manure is the best. In cities the sweepings from the streets have been utilized. Manure from livery-stables and streets should, however, not be applied too fresh, and should be especially well mixed with the soil. Apply manure before ploughing or spading and then turn under. Heavy and clayey soils also need manure to make them more porous. Frequent and deep tillage, however, renders soil more porous. Application of lime keeps clayey soil from cracking. Wood-ashes is a good fertilizer, and should be saved for that purpose. A little mixed commercial fertilizer (consisting of nitrogen, potassium, and phosphorus compounds) may be applied after ploughing or spading, and raked in. The rough soil should be well harrowed or raked, all lumps broken and stones, etc., removed. The ploughing or spading should be done about the first of April.

PLANNING THE GARDEN: Begin early, in March or earlier, to plan the garden. Decide upon the number of beds,

whether group or individual, and make a plan on paper of the garden area. Measure the whole area to be used, and divide it among the different grades that are to do gardening. The lower grades do not need such large beds, and where space is limited they may work on a bed as a class or by groups. The children are to do the work of surveying, as it gives them good practice in practical arithmetic and measurement. Let them represent in a plan the whole school garden and their particular portion. Then have them take the class garden and divide it up among the children of their class who are to do the work. The garden, if all in one piece and large, should have a walk all around, from two to five feet wide, and also walks of about the same width between the rows of beds. The individual beds should preferably run east and west, and be planted with crosswise rows, to give the best distribution of light. The beds should be oblong rather than square. Make them four or five feet wide and as long as space will allow. The individual beds should be separated by walks about eighteen inches wide. Long and narrow beds permit of easy weeding and hoeing from the paths. The class garden, and individual or group beds, should be well marked with stout stakes at the corners. Use a tape-measure and marking-line, and be careful about getting the lines straight and square. Later, after the seeds are selected, let each pupil plan and mark off his own bed. The beds should be named or numbered on one of the posts. The little children will need a good deal of help in this, and even the older ones will need watching to see that they follow directions. A garden note-book for writing the various directions for work would be useful. Be very specific in giving directions.

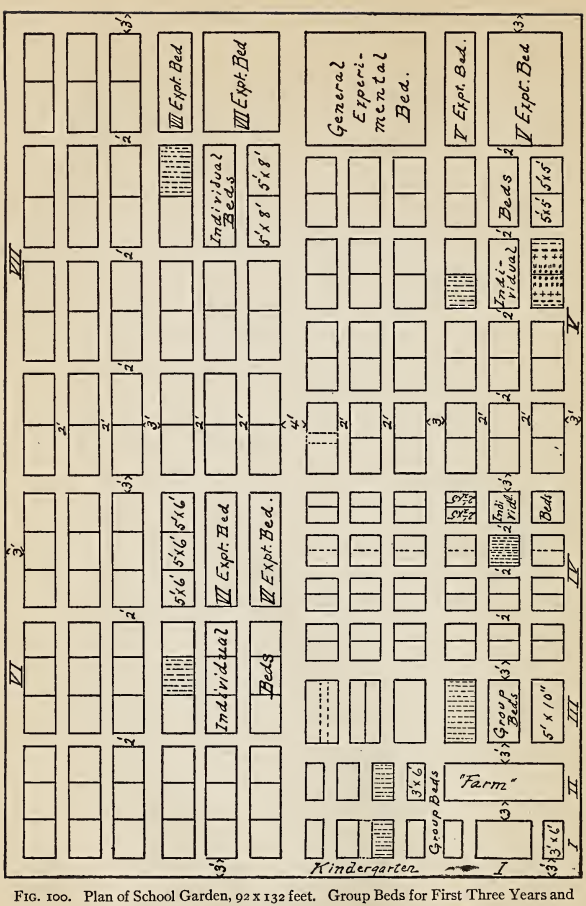


FIG. 100. Plan of School Garden, 92 x 132 feet. Group Beds for First Three Years and Kindergarten.

Forty-eight individual beds for Grade IV; forty-eight for Grade V; forty-eight for Grade VI; forty-two for Grade VII; and several general experimental or ornamental beds. Where space is sufficient the individual beds may be entirely surrounded by paths, and both beds and paths may be larger. Much smaller beds will not be profitable as individual plots. In smaller quarters some of the paths may be

Tools: The school should furnish good stout tools for the garden work. These should include several light spading forks, several shovels, a number of ten or twelve tooth rakes, a set of medium hoes, hand weeders, hatchets, marking cord, measuring tape, watering pots, etc. These should be well cleaned after using, and hung systematically in a dry place.

Selecting and Buying Seed: Early in March, or even in February, make the selection of seeds. You will want to start some in the house early, and the order may be delayed. Let the children make the selection generally, but see that they do not select seeds not suited to the purpose or to their ability. Large seeds are best for the lower grades, and the more rapid and hardy growers should be selected for them. Send for seed catalogues. The magazines and family journals will have numerous advertisements of seed houses in their columns. Read up in books on gardening. A number of magazines and farm journals usually have garden notes. Let the children have these catalogues, etc., to look at.

It would be better and simpler for the lower grades at least to make a uniform selection. Seeds may be bought at club rates for about a cent per package, or they may be purchased in bulk and distributed in school. The latter is probably the better way with small classes, when each child needs only a few seeds. The children should pay for them, unless there is a school fund upon which to draw for

sacrificed by bringing the beds together at the ends. By placing the beds of Grades VI and VII in line with the rest, a long, narrow garden may be made, better adapted to the edge of the school grounds. Whatever the shape or size of the garden a unit bed should be adopted. In this garden the bed is five feet wide and varies in length with the grade. A bed of this width can be easily weeded or hoed from the sides. The rows should run across the beds. In this garden the rows run north and south, which distributes the light best in the rows of plants. In the double beds it is well, for looks, to have the plantings of the two beds match, as shown in lowest row, Grade V, the taller plants being in the middle.

the money. Well-equipped schools with large gardens should furnish the money for the seeds. As a rule, seeds for home growing should be purchased by the children themselves. In many cities there are associations or social settlement societies that sell the seeds to the children practically at cost. The local civic improvement society may be induced to undertake such assistance. Such work is done notably by the Cleveland Home Gardening Association, and also by the Massachusetts Horticultural Society. On application the United States Department of Agriculture sends out gratis to schools a limited number of flower and vegetable seeds. A useful bulletin on gardening also accompanies them. Order early, and state definitely the kinds and the quantity of seeds wanted. (See directions for different grades under Gardening in the Course of Study.)

Planning the Planting: Let each pupil or group arrange the planting of the individual or group bed. Make a plan on paper. A uniform plan should be required. The size of the plant and the light conditions must be taken into account. The flowers should be planted in the front, except the very tall ones, which should be placed in the rear of the lower or, at any rate, on the north side, so as not to cut off the light from the rest. Tall sunflowers, hollyhocks, corn, etc., and vines, should be planted against the fence or building, if the garden is there. The rows should be at least wide enough to allow hoeing, and a foot apart would not be too much for the average. The larger plants, such as tomatoes, cabbages, and running vines must have proportionate room. If planted between rows of the early maturing kinds of vegetables, they may be given more room later by pulling up the others.

PROGRAMME: There is less confusion and fewer tools are needed if the classes work at different hours or on different days. A schedule of work should be arranged. Much of the gardening can be done after school or on Saturdays.

PLANTING TIME: Get the soil ready about the last of April, and procure the seeds early, but do not be in a hurry about planting. In general, seeds should not be planted till about apple blossom, or corn planting time. Seeds for the fall flowers and vegetables really need not be planted till later. Unfortunately school will close before the plants are in flower or the vegetables large enough to eat. Candytuft and sweet alyssum possibly will be just beginning to flower, and lettuce and radish to be available. For spring returns one will have to depend upon bulbs, perennials, and flowering shrubs. It will be a great deal better to plant for autumn returns in the school garden, unless the work is to be continued as a vacation school. The usual school garden will be the most useful for nature-study purposes and look the prettiest in the fall. So do not be in a hurry to plant, but wait till the frosts are well over. For early results it is customary to use sweet peas, garden peas, poppies, lettuce, radish, and onions as soon as the ground can be worked, even before frosts are over. These are hardy. Sweet peas planted late, however, will bloom longer in the fall than those planted early, and these early ones will be in flower by the time school closes for summer. Sometimes

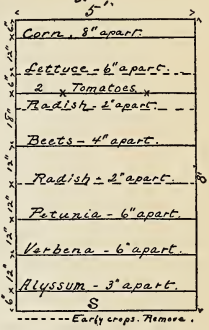


FIG. 101. Plan of Individual Garden where the Rows have to Run East and West.

by forcing seedlings in the house, cold-frame, or hot-bed, some flowers, etc., may be had by the close of school.

For home and vacation gardens early varieties should be chosen as well as late, so as to furnish flowers and vegetables all through the season. By successive plantings at intervals of several weeks several crops can be had.

How to Plant and Sow: If the directions for sowing are not upon seed packets for each pupil, give very careful instructions. The soil should be well pulverized. Lines should be drawn straight across the bed, and furrows made with the hand or the end of the hoe or rake handle. Do not make the furrows too deep. Seeds may be buried so deep that they cannot reach the surface. In general, they should be planted at a depth equal to about three or four times their thickness. Peas should be covered extra deep, three or four inches. But the very small seed should be simply sown on the surface and lightly sifted over with fine soil, or washed in with a very fine spray of water. This applies to such seeds as petunia, portulaca, and poppy. Many seeds are benefited by a preliminary soaking over night to hasten their germination. It is also a good thing to firm the soil or press it tightly about the seeds. After they are planted they need to be kept moist till they have sprouted and have made a good start. Seeds will not germinate in dry soil, so water regularly and thoroughly. Do not sow too thickly, but fairly thin and evenly. Where a few plants only are to be desired in a row or hill, it is well to put in a few extra seeds to make up for those that will not germinate. They can be thinned out later if not needed. Beware of old seeds. Some seeds will germinate when several years old, but most of them lose their vitality rapidly after the

first year. It is not necessary to plant all the seeds at one time. The less hardy ones should be sown later. Mark each row with a wooden peg on which the name of the plant sown is written. This will also help to tell where the last seeds were planted.

CULTIVATION: Each pupil or group in charge of a bed should be held responsible for its care. Weeds need to be constantly pulled or hoed. Hoe in the walk and pull in the rows. Teach the children to distinguish weeds from the plants cultivated. Give lessons on weeding and hoeing. It is best to hoe weeds on hot dry days, for then they will not be so apt to strike root again, but will dry up. Weeding by hand should be done when the soil is damp, for then the roots of the weeds pull better. Make studies of the common weeds as they appear. Teach how to recognize them in the early stages, and describe their appearance later, the harm they do, and the best way to get rid of them. Hoeing or loosening the soil with the rake or hand weeder is necessary even if there are no weeds, for this breaks up the hard crust of earth and pulverizes it so that it retains the soil moisture better. It acts as a kind of mulch and helps the roots in penetrating the soil. After several years of good cultivation the weeds will not be so abundant, especially if commercial fertilizer is used. Manure that is not well rotted is apt to contain many weed seeds.

WATERING: This may be necessary to make the seeds sprout, but later it is not so necessary. In very dry periods it should be done thoroughly. A little thin sprinkling on very dry soil does no good, and simply helps to cake the surface. Put on plenty of water to thoroughly drench the soil. It is better done at evening, for then the sun

does not harden the surface so much, and the change of temperature is not so harmful to the plants. Watering is needed more in sandy and porous earth. Loosening the soil by frequent tillage is often better than watering. That is what is meant by "watering with a hoe or a rake." A mulch is thus formed that keeps in the moisture.

CARE DURING VACATION: This is the most serious problem with our American school gardens. Our summer vacations are so long that there is great danger that the garden will perish from neglect. An effort should be made to get some one to look after it once in a while during the summer. The janitor of the school often takes pride in the garden, the lawn beds or borders, and will see that they are kept in condition. Often children in the neighborhood of the school may be got to take care of the garden during the summer. They should be given the flowers and summer crops as a reward. Yet I have seen country school gardens doing fairly well and looking pretty during the summer months, when they were left to shift for themselves. A last thorough weeding may be given at the close of school, and then, if the summer is not too dry and hot, the garden will come out in a fairly good condition after all. Of course it will be overgrown with weeds, and the plants will sprawl over each other for lack of training; yet by carefully pulling up or hoeing between the rows, and by cutting out with shears the weeds in the rows, pruning the plants, tying to stakes, and other "sprucing up" the garden will still be very presentable, and be very useful in furnishing bouquets, etc., for the school. In fact, a neglected garden may be made to furnish some excellent lessons in the study of weeds, overcrowding, insect effects, etc. So I would urge the

attempt to make a garden, even where the conditions for the summer are unpromising. Our field crops generally have to get along without watering in the worst of droughts, and the grains cannot be cultivated. Even so a school garden can worry through the summer. In case no special care can be given through the vacation, only the hardiest plants should be planted.

STARTING SEEDS INDOORS: Time can be saved and flowers and vegetables obtained earlier by starting seeds in the house, cold-frame, or hot-bed. But though the seeds are planted two months earlier than those sown outdoors, the flowers will not appear that much earlier, perhaps only half as much earlier. The checking on transplanting to a cooler atmosphere usually retards the growth somewhat.

Pansies, asters, nasturtiums, lettuce, cabbage, cucumber, tomato, etc., are thus started early in March. Sow the seed in shallow boxes of earth, grape baskets, etc. Keep moist at first by covering with a glass pane, and keep in a warm place till germinated. After that give plenty of light and not too much warmth, else the seedlings will grow spindling and weak. On mild days set outside on the window ledge or elsewhere, in order to make the plants grow stockier and healthier. When they have formed several leaves, not seed leaves, they should be pricked out and replanted several inches apart in new boxes or flats. This will give them more room and develop a better root system. If set outside in daytime do not forget to take them in at night.

COLD-FRAME: In many respects a cold-frame is more convenient than the indoor method of starting seeds, especially where many are grown. A cold-frame is made by constructing a rectangular box or frame, setting it in the earth, or banking

it up well, and covering it with a glass roof. An unused storm window may be used for this. By that time storm windows will not be needed on all the windows, and one can be taken from the school. Plant seeds in the frame about the first week in March or later. Keep the soil well moistened. The sun's heat is kept in the frame and forces the seedlings. At night it may be necessary at first to put an extra covering over the frame. Later, on warm days, the window roof should be raised and the air allowed to enter. Still later the window may be taken off during the day and replaced at night or on cool days. Plants raised here are more hardy and healthy than those started indoors. If too thick they should be pricked out and transplanted to another frame. The plants started earlier indoors may be taken up and set in the cold-frame.

HOT-BED: This resembles a cold-frame, only it is deeper and has a thick foundation of about two feet of fresh horse manure, under the growing soil of about four or five inches. It is covered with glass. The purpose of the manure is to produce an artificial heat by its decay or fermentation. The box may be set deeply into the ground, or raised and banked up with manure. At first the temperature may be too warm for sowing, but after a few days, when the average temperature is about 80 degrees, the seeds may be sown or the seedlings transplanted to it. A thermometer should be hung in the hot-bed, and when it registers more than the above temperature, the glass should be raised more or less to ventilate. As the hot-bed requires considerable care and judgment, it is not advisable to let the little children grow plants in it. Plants raised in a hot-bed often suffer a severe setback in their development, unless very carefully hard-

ened by proper ventilation or gradual transplanting to cold-frames. But for forcing early vegetables and flowers the hot-bed is very useful. Hot-beds and cold-frames should be placed in sunny situations, on the south side of houses or walls. Start a hot-bed in the middle of February or in March.

TRANSPLANTING: When the danger of frosts is over, seedlings of flowers, lettuce, cabbage, tomato, etc., started indoors or in frames, should be transplanted to the garden beds. Transplanting should be done, if possible, on a cloudy day or toward evening. Dig up carefully a seedling with a good cluster of roots damaged as little as possible. Do not shake off the earth on the roots, and do not pull the seedling up. Place it in the ground at the same depth as it grew before. Press the soil tightly around the roots and water well. If necessary, protect from wilting by sticking in shingles on the south side, or set a board on edge along the south side of a row, or flat on pegs over the row, if north and south. A cloth shade on sticks, or even a newspaper pegged down over the plants, will answer for a few days till they recover from the shock.

Some kinds of plants, such as the morning-glory and cucumber, do not bear transplanting well. They may be started in berry-boxes lined with paper, and the boxes may be gently broken away and the plants set into the ground without injury.

It would be well to put a few of the late flowering plants, such as chrysanthemum and salvia, and the late maturing plants, such as cotton, into pots, pails, or boxes that could be taken up when cold weather comes, so that the plants may continue to grow in the house. Such vessels can be sunk in

the ground. Geraniums, begonias, and fuchsias also should be left in the pot, but sunk.

THINNING OUT: It is a great temptation to let all the plants stand that come up. This, however, should not be allowed if they grow thickly, for they will not all mature, and none of them may attain a normal size. Thinning out should be done relentlessly. Consider the size of the adult plant and thin out to accommodate that. This does not mean necessarily that the pulled plants must be wasted. If carefully pulled or, better, pricked out, they may be given away to those who have none, or they may be stuck in out-of-the-way places, and used for replacing such as may have met with accident in the main beds. As a rule, let the largest and best-developed plants stand.

EXPERIMENTAL BEDS: In large gardens considerable experimental culture may be carried on: Certain varieties of grain, vegetables, or flowers may thus be tried. Sugar beet cultivation may be demonstrated, and the method of improving corn by selection also shown. The beneficial effect on the soil where alfalfa, and other legumes have been grown may be demonstrated, or different methods of fertilizing may be tried. Such experimental plots should be set aside for general care, and be placed outside the individual bed area. Likewise a bed or space should be devoted to a tree nursery, and a small fruit patch should be set aside.

FRUIT GARDEN: Where space is available let an orchard and a vineyard be planted. In the course of a few years these would be very interesting and useful parts of the garden and campus.

ORNAMENTAL BEDS: Where a garden is cultivated for the practical lessons of planting, etc., attention should also

be given to the beautification of the school grounds with flower beds, borders, etc. These should be filled with bedding plants and left largely to the care of the pupils, different groups taking care of different beds. Such beds require changing of the plants when the first lot have finished flowering. In the fall, bulbs should be set for early spring flowering. They make a most beautiful effect when placed rightly. After these have withered they should be taken up, or later flowering plants should be set among the bulbs. Sometimes it is more advisable to plant foliage plants that are not conspicuous for their flowers, but produce elegant effects with their beautiful large leaves. Place such beds around the edges of the grounds, along the walks, in angles of the buildings, along fences, etc. A very good place for border beds is in front of shrubbery. In such beds it is well to take into consideration color schemes. The proper colors should be placed beside each other, complementary colors, as a rule, setting each other off to advantage. Often it is better to have the beds just one color—white, pink, or yellow. This is better than having a great variety of colors. Low spreading plants like sweet alyssum, verbena, and portulaca are good for borders along the walks, and in front rows of beds or borders along shrubbery or fences. Behind them should come the taller forms in succession. In such borders it would be well to select the plants so that some of them would be in blossom all summer. Plants that have withered or are through flowering should be removed or cut off. It is generally better for plants to have the flowers picked, for if allowed to go to seed they will stop blooming sooner. This applies especially to sweet peas, nasturtiums, and pansies. A few of the best developed of the earlier

flowers should be allowed to go to seed. These, when ripe, should be collected by the children and saved for next year. This is an important part of the gardening work, much neglected in the home garden and at school. (See also Chapter XVIII on the beautification of grounds. For lists of bedding plants see page 296.)

Bulbs for Outdoor Culture: The gorgeousness and beauty of spring bulbs make them very desirable in school

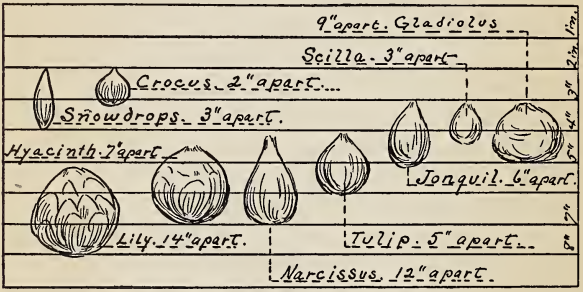


Fig. 102. Bulb Diagram for Outdoor Planting.

gardens. While the garden is being prepared and the children are waiting for the seeds to come up, they will be delighted and encouraged by the growth and flowering of these beautiful bulbs. They are so easy to raise that every kindergarten ought to cultivate them. Tulips are the best, as a general thing, and there are many different patterns and colors of them. Crocus, daffodils, hyacinths, and German iris are also excellent. It is best to set the bulbs in September or October, and when the frosts begin, to cover them with a mulch of straw or leaves for the winter. The beds should be either raised or well-drained with broken

tile, bricks, etc., before filling with rich loam. In the spring the litter should be nearly all removed, and when the leaves come up the rest should be taken away. The bulbs should be set at depths indicated in the accompanying diagram. The children will delight in the fall planting, and will be looking for the flowers in the spring. Bulb beds require no more care than here mentioned. Tulip bulbs may be left in the bed for flowering in other years, or they are sometimes taken up when the leaves have withered, and their places filled with summer-flowering geraniums, foliage plants, etc. They are stored in not too dry a place, and planted again in the fall. If left in the ground, small-rooted plants like pansies, portulaca, alyssum, etc., may be sown or planted among the bulbs.

For summer flowering the gladiolus, canna, and dahlia may be planted. Their bulbs or roots, however, are tender, and must be taken up for the winter. The gladioli and the large cannas are very showy. The dahlias are excellent border plants, and bloom into the fall.

PERENNIALS, SHRUBS, VINES, ORNAMENTAL TREES: (See Chapter XVIII, "Beautification of School Grounds." Also see lists of plants for this purpose, page 296.) The planting of these is often about the only thing that can be done in the way of school gardening except the window-box gardening. Many a school ground could be beautified by the planting of these easily grown plants, which, once established, require no further attention than a little training, trimming, and perhaps winter covering. As a rule, they should be planted with some idea of the requirements of landscape gardening. Never let them encroach upon the playgrounds. They may be safely planted along fences, boundaries, buildings, and in the corners of the grounds. Here they will be

less molested and trampled, and will look better. They should be selected so that some of them will be in flower at different times throughout the season.

In this list may be placed many autumn wild flowers. Clumps of goldenrod, wild asters, coneflowers, etc., are very ornamental and appropriate in our gardens.

Wild Flower Garden: (See list, page 297.) The wild flowers can give as great pleasure as the more aristocratic and costly cultivated kinds. In shady situations, on the north side of houses or fences, wild flowers may be grown where most of the cultivated kinds cannot. To do well they need, however, rich wood soil, and a mulching of leaves or straw in the winter. Bring them in from the collecting trips. They make a very useful botanical garden for lessons on plants.

Fernery: A plant need not have flowers to be called beautiful. Every one would class the ferns with the beautiful plants. Their lacy fronds, curious crozier buds, woodsy fragrance, and somewhat tropical effects make them admirable for decorative borders. They will grow in shady or damp places where other plants will not. Get ferns from the woods and cliffs, in the dryer situations. Dig up with abundant roots the underground stems of the bracken fern, ostrich and cinnamon fern, cliff brake, and the maidenhair. Place them in a deep bed of rich wood soil, with pieces of decaying logs, sawdust, peat, etc., well mixed with the soil. It is well to dig deep first, and provide drainage with broken brick, tile, cans, etc. Ferns look very well around the school entrance, in corners, and among shrubbery. In the fall they need some protecting litter, such as wood soil or leaves.

ROCKERY AND BIRDS' TROUGH: In some far corner of the grounds, where the birds are more apt to come, build a mound of dirt, set boulders and rocks in the surface, place a drinking trough on it for birds, and plant with ferns, wild flowers, vines, nasturtiums, etc. A more permanent structure may be made with rocks and cement, perhaps provided with a water pipe for a fountain. Potted plants could be set about it, or put into pockets left for the purpose. In many places wild birds would be attracted to it, to the delight of the children.

GREENHOUSE WORK: A few schools may be so fortunate as to possess a real greenhouse. In that case the following suggestions can be carried out more completely. But even where no such conveniences exist much can be done. The window garden can be utilized for such work, or a small outside or inside bay-window may be constructed of sash and used as a miniature greenhouse.

POTTING SOIL: For most purposes the following mixture will do,—loam, manure (or wood mould), sand—equal parts.

FERTILIZER: Manure, commercial fertilizer, or bone ash may be stirred into the soil about the roots of plants in pots and boxes. Watering once a week with liquid manure is also good for stimulating plants.

POTTING: Do not use too large a pot for flowers, and allow about an inch all around the root mass of the plant. Put some stones or broken pot in the bottom for drainage. If in cans, punch holes in the bottom. The plant should not be set deeper or higher than it grew before. Do not fill the pot completely, but leave space for watering.

REPOTTING: This is necessary when the roots of the plant have covered the mass of soil inside the pot with a

felt of fine roots. Before they turn dark the plant should be transferred to a pot an inch larger. Tip the pot, hold the hand over the earth, and slightly tap the edge of the pot against a table to loosen it. Put into a new pot as directed above, removing some of the old soil from the top and margin.

Watering: Do not water except when the plant needs it. Then give a good soaking. But do not allow the soil to remain soggy all the time, for that injures most plants. The roots need air as well as water. The soil should be moist, but not soaking.

Turn the Plants to make them grow symmetrically, else they will develop mainly on the side toward the light. Do not crowd the plants in a window so that they cut off each other's light.

Window-boxes: These should be not less than eight inches deep, about the same in width, and as long as the window permits. Put drain holes in the bottom. A metal tray to catch the moisture would protect the sill. Oilcloth, however, will do as well, if the box is raised slightly on strips of wood placed under it to allow the moisture to dry. The boxes should be well made. They may be made of galvanized iron, or more cheaply of wood. They should be painted to prevent warping as well as for looks. Use the potting soil given above.

These window-boxes may be used in a variety of ways. To a certain extent the principles of gardening can be taught with them. Germination studies, soil studies, starting of plants for the outdoor garden, experiments on plant behavior, planting of tree seeds and pits, the propagation of plants by slips, layering, and grafting—all these things can be demonstrated in the little window gardens.

Where the school building is heated so that the plants will not freeze at night or during holidays, this indoor gardening can be done in the winter. Otherwise it will have to be deferred till later in spring. Aside from the above practical uses of the window-box it may be used for growing plants

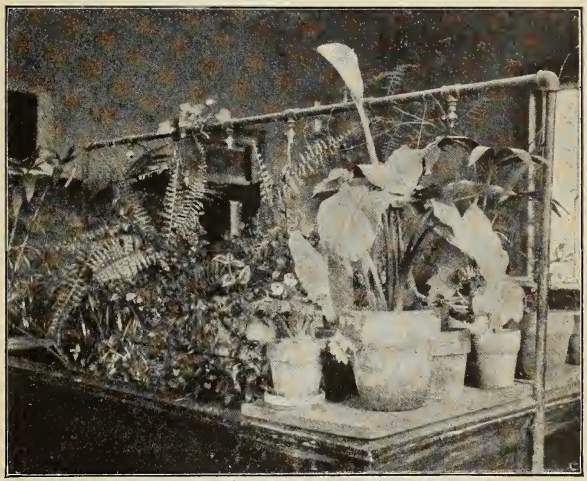


FIG. 103. Plants Growing in the Laboratory Above an Aquarium.

for decoration and pleasure. It is always a pretty sight to see potted and window-box plants in a school-room. It looks cheerful and home-like. Even these plants can be utilized in many nature lessons.

During the summer the box should be filled with plants, set on the outside window ledge, and placed in charge of the janitor. The plants will need frequent and thorough watering, as their soil depth is not great. (For in-

door plants for pots and boxes as well as for outdoor boxes see list, page 297.) The plants should be selected according to the light conditions. Rooms on the north side must necessarily confine themselves to such plants as will flourish in the shade. It is generally out of the question to try to raise flowers on the north side. A geranium would probably starve there, and would certainly not flower. I would suggest that, if flowers are desired, boxes be placed on the south side till the flowers appear, and then that they be transferred to the north room. There are, however, a number of foliage plants that do fairly well on the shady side, and these are given in the list on page 297. To my mind a window with flourishing ferns, begonias, periwinkle, and wandering Jew is just as beautiful as a box of flowering geraniums. Aquaria with goldfish will give a touch of color, if placed among these shade-loving flowers.

The boxes should be set with a variety of plants, drooping kinds in front, climbing vines to train up the window at the ends, taller plants in the centre. Some set the plants in the pots into the box and fill the space between them with moss or earth. This permits the turning of the plants. In dusty schools the leaves will need washing often. Sometimes, if started in midwinter, annuals like pansies, petunias, portulaca, nasturtium, and sweet peas can be brought to flower in March or April.

Bulbs: It is always a pleasure to raise bulbs indoors. To do this plant them so that their tops are about an inch below the surface. Plant them any time from September to January. Set them aside in a cool, dark place, such as a cellar or dark attic. Water them well at first, and after that enough to keep them from drying out below. Leave for three

or four weeks for the roots to form. When these have been well developed, bring the pots or box to the light into a warmer room. When the tops appear, give plenty of light and water. They will now grow rapidly and soon blossom. Tulips, narcissuses, crocuses, hyacinths, freesias, etc., are good for such culture.

CUTTINGS: Plants for summer bedding in the borders may be started from slips or cuttings made in winter. The best flowering geraniums are those started early in the winter from cuttings. To make cuttings select such parts as break with a snap, and cut pieces with about two joints. Trim off large leaves or cut off half the blade to reduce evaporation, set into clean, sharp sand in shallow boxes, and keep the soil moist and warm. When the cutting has made sufficient roots, in about four or six weeks, it may be taken from the tray and potted. Coleus, fuchsia, carnations, and many other plants can thus be propagated. Begonia leaves cut into pieces, and partly covered with soil will form new plants readily. An interesting experiment is to take a large leaf of a bryophyllum plant and hang it up, preferably in a moist, dark place. The leaf will form numerous buds around the margin, which may be cut out and planted. Cutting a potato into pieces for planting is similar to making slips. The pieces should have one or two eyes.

Roses also may be grown from cuttings. The best wood for such is taken from just below a flower. Cut the wood into as many pieces as there are buds.

Willows, lilacs, grapes, and many berry shrubs are grown from cuttings made of twigs, in the dormant condition in fall or winter. Cut the twigs into lengths of from 8 to 12 inches, each with several buds or joints. They should then be

buried in a cellar or some other place in well-drained sand or soil, and the cuts allowed to heal. The next spring they may be planted where wanted permanently, or first set in temporary rows. Set vertically or slanting, so that only the upper bud projects. Choose well-seasoned wood for such cuttings. Many such cuttings may be had for nothing in the fall pruning of vineyards or berry gardens. Raspberry, blackberry, woodbine, ivy, etc., may be grown from root cuttings in a similar manner.

Layering is similar to cutting, except that the branches are first left attached to the parent plant, but are fastened down to the ground and covered with soil at certain joints. At these places roots form, and, when well established, the layer may be severed from the parent and planted independently. Carnations, and other house-plants may be treated thus, also currants, gooseberries, raspberries, etc., grape, and woodbine. These should be layered in the nursery or berry patch. Roses also may be propagated in this way. Many plants, notably the strawberry, form runners for a similar purpose. Practise the setting of strawberries developed from runners.

Grafting: Akin to the above methods of propagation is grafting, by which a stem or bud called the scion is made to grow on a root or a stem of another plant called the stock. The latter is usually a more hardy grower than the scion, while the scion is of a choicer quality. Twigs or buds from a very desirable fruit tree, such as the navel orange, may be set on a wild variety, or on one inferior in fruit but very hardy. This is extensively practised by fruit raisers for propagating the best varieties of fruit. The seed of these fruits cannot be depended upon to come true, hence the im-

portance of grafting. There are many different forms of grafting. Several of the more common methods are given.

Root Grafting: This consists of growing choice scion stems or twigs upon hardy roots. The stocks are usually grown from seeds, and may be those raised in the school nursery or may be bought at slight expense. The scions are cut in the dormant state in midwinter, and kept in sand in a cool and moist place till grafting time, usually in March or April. Let the children bring twigs from choice kinds of apples. Cut pieces several inches in length with three or four buds. When ready to graft, clean the scions and stock. Cut pieces of root six or eight inches long, and about a quarter of an inch thick. The stock of the apple must be about two years old. The twigs of the scion should be from well-seasoned wood of the last season's growth. With a sharp knife cut the top of the root and the lower end of the scion at the same slant. Select stocks and scions of the same diameter if possible. Cut out a thin wedge from each

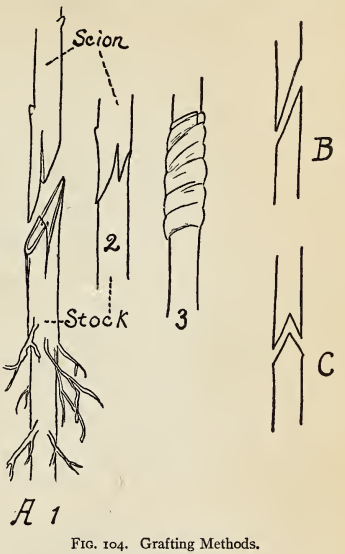


Fig. 104. Grafting Methods.

A. Tongue-grafting.
1. Stock and scion separate.
2. United.
3. Bound with grafting-cloth.
B. Plain whip-grafting.
C. Saddle-grafting.

surface, and press the scion firmly into the stock, as shown in the figure. The inner bark of the two must fit together. This is known as the tongue graft. Other methods are suggested in the other figures, and may be tried. The two pieces should now be bound tightly together. For this use ribbons of cheese-cloth or muslin, made by covering with a melted mixture of four parts common resin and one part beef tallow. When cool, roll the grafting cloth, as it is called, into the roll and use as desired. This cloth should be used in strips about half an inch wide. Wind it spirally around the graft to hold the two parts firmly in place. The cuts at the end of the scion should be covered with grafting wax, made of four parts resin, two parts beeswax, and one part tallow. When cool pull like taffy till of a buff color. Form into sticks. The grafted plants should then be set away in cool, damp sand, in a cellar or elsewhere, to lie dormant till spring, when they are to be set out in the nursery.

Twigs on trees or shrubs may be grafted in a similar manner. Thus we may make different kinds of apples, and even pears and other related species grow on the same tree.

Technically the grafting of a bud on a stock is called Budding. It is done in summer or early in September, when the bark will still peel easily. Twigs from the desirable trees are cut, and from these the buds are cut off with a thin shield of bark and a little wood. Remove the leaf that is beside the bud. Make a longitudinal slit in the bark of the stock seedling on the north side, and cut across its top a horizontal slit. Peel back the bark slightly, enough to allow the insertion of the shield of the bud. Push the bud in and press back the bark of the stock over it, leaving the bud

slightly exposed. Tie with soft twine or raffia to hold the bud in place. After about two weeks the bud will be attached, and the binding should be cut to prevent the strangling of the stock. In the next season, when the bud has be-

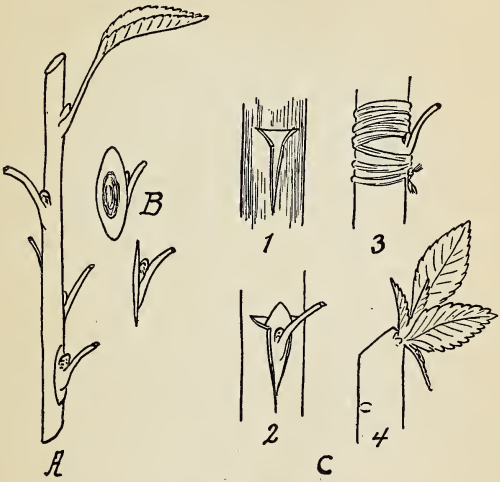


FIG. 105. Budding.

A. Bud-stick with buds.
B. Buds cut out of stick.
C 1. Bark of stock slit open.
C 2. Bud partly inserted under bark of stock.
3. Bark of stock tied over bud.
4. Stock cut off after bud has grown.

gun to develop, cut off the stock just above the inserted bud, so as to give this all the nourishment, and to prevent the other variety from forming branches and fruit. Cover the cut with wax. Care must be taken that the stock does not send out branches or suckers below the graft. If any form they should be removed. Peach, apple, pear trees and roses are thus budded.

Pupils will find grafting very interesting work. They should be encouraged to continue to practise it at home.

Competitive Culture: It is an interesting experiment to have the children cultivate plants at home to see who can raise the finest. In lower grades this competition may be in flowers and simple vegetables. In the upper grades, especially in the rural villages and schools, this might be made very practical. Here the boys, especially, could select seeds of the best sort, and try different methods of cultivation or fertilizing special crops, etc. A very practical thing would be to raise corn or sugar-beets in competition. In such competitive culture it is to be understood that the children should have no assistance from parents or any one else. A certain number of seeds, bulbs, or slips may be given to each, along with specific directions for planting and for the care of the plants. Then let each child be held responsible for their culture. Of course there will be many failures, yet even from these sometimes valuable lessons may be learned, if not in plant culture, perhaps in self-culture—persistency, regularity, forethought, etc. In some cities there are public societies that further such work by furnishing the seeds or giving prizes.

The different schools in the town might join in a competition for the best general school garden, or the best borders, or window-boxes, or the best arrangement of the shrubs, beds, etc. Of course this will not mean much to the children if the work is done by the teachers, the janitor, or some hired gardener. It should represent the efforts of the pupils of the school. Then they will take more interest and pride in the work, and will look after it more. Committees should be appointed to visit the various schools at different times in the season to adjudge the reward.

Connected with this is the matter of EXHIBITS of the garden products and related work. Soon after school begins in the fall let there be a fair or exhibition of the plants raised at home in competitive culture. Have the vegetables of the school garden neatly displayed. Have bouquets of flowers from the school garden artistically arranged. Utilize the window-boxes and the potted plants for ornamental effects. Other nature work might be displayed at the same time—art work based on nature-study, written work, notebooks, charts, etc. Also have collections of weeds from the garden, with descriptions and remedies, herbaria of flowers, insect collections, to show economic relations, life histories of insects, cages with insects, etc. The patrons of the school would be much interested in all this. Show them what has been done in the garden. Write up the event in the papers, take photographs of the exhibit and also of the garden, etc. All these things encourage the children, and serve to interest the public in the work of the school.

I suggest that the older grades be allowed to exhibit some of their garden and horticultural work at the county fair with exhibitors' privileges.

INTEREST IN AGRICULTURE may be aroused in the older children by letting them read books, journals, etc., on the subject. We have now many good books on elementary agriculture. Put these into the hands of the pupils. A good garden or farm journal would be a useful addition to the school periodical list. The farmers' bulletins of the United States Department of Agriculture should be utilized in this work. Encourage the boys to send for them, and get the bulletins from the State Agricultural Schools and Experiment Stations, and the catalogues from these institutions and from

the County Industrial Schools. Many a boy should be encouraged to go to such a school, The older pupils should visit such schools if near, and also attend some of the sessions of local farmers' institutes. In this way the pupils are shown the possibilities of farming, and also the advantages of farm life.

Books on Gardening: Seed and nursery catalogues, which may be had free from any seed house or nursery, are full of specific cultural directions for the different plants, and also contain much general information about insecticides, fungicides, etc. Some of the popular family and farm journals have useful suggestions for gardening. Some of the best books on gardening will be found in the reference list in the Appendix, page 517.

Insecticides and Fungicides: A complete list of these need not be given here. Various eed houses have special commercial preparations for different insects, rusts, etc., but the following are among the most universally useful:

Cut-worms are very troublesome in the spring when the plants are young and tender. Tomato, cabbage, sweet peas, etc., are bitten off near the ground, and drawn into the burrows by the worms. To kill them place a spoonful of poisoned bran at the base of the plant and among the rows. This is a bait the worms will generally eat, especially if placed there before the plants are up or are set out, and there is nothing else to eat. If the plants are few, then a stiff paper collar may be pinned around the base of the plant and set somewhat into the soil. The worms cannot climb over this. Toads placed in the garden are useful friends of the gardener. Let the children bring in the toads they find and liberate them in the garden.

FOR LEAF-EATING INSECTS—apply with a sprayer:

1 ounce of Paris green dissolved in six gallons of water.

FOR SAP-SUCKING INSECTS—apply with a sprayer:

Make a mixture—called emulsion—of the following:

2 gallons kerosene,
1 pound of hard soap,
1 gallon water.

FOR RUSTS, ROTS AND BLIGHTS—PLANT DISEASES:

1 pound of unslacked lime,
1½ pounds of copper sulphate.

Dissolve each separately in about six gallons of water. Use wooden pails. Mix thoroughly and apply with a sprayer.

This may also be made an insecticide by adding to the mixture about two ounces of Paris green.

Plant Lists for Different Purposes

VEGETABLES, etc., suitable for the school garden:

(Those marked * are easy for the little ones.)

FOR SPRING: Lettuce,* radish,* onion sets.*

FOR SUMMER: Peas,* beans,* beets,* turnip,* sweet corn,* cucumber, muskmelon, watermelon, tomato, egg-plant, early cabbage, cauliflower, carrot,* onion, late lettuce, pepper, grains,* cotton, flax,* sugar-beet, sorghum,* potato.*

FOR AUTUMN: Field corn,* pop-corn,* pumpkin,* squash, sweet-potato, celery, tomato, pepper, cabbage (late), carrot, beets* (late), turnips* (late), onion, parsnip, sugar-beet, peanut, cotton (plant some in pots).

ANNUAL FLOWERS:

(Those marked * are easy to grow for the little children.)

SPRING FLOWERING: Sweet alyssum,* candytuft,* bachelor's button.* Must be started early.

SUMMER FLOWERING: Pansy, balsam,* portulaca,* sweet alyssum,* candytuft,* bachelor's button,* morning-glory,* California poppy,* sweet pea,* petunia,* mignonette, amaranth, pink,* poppy,* stock, scabiosa, castor bean,* calliopsis (or coreopsis),* single and double

sunflower,* scarlet runner,* cosmos,* verbena,* nasturtium,* salvia, four o'clock, prince's feather, calendula (pot marigold),* African or French marigold,* phlox,* canary-bird vine, nicotiana,* wild cucumber,* zinnia,* early aster.

AUTUMN FLOWERING: Pot marigold,* zinnia,* cosmos,* nasturtium,* marigold,* verbena,* nicotiana,* calliopsis,* chrysanthemum (in pots set in ground), mignonette, castor bean,* cosmos,* prince's feather, scarlet runner,* sweet pea,* salvia* (plant some in pots), aster, stock, pansy, petunia,* canary-bird vine, morning-glory,* larkspur,* kochia (mock cypress).

GOOD FOR BEDDING:

(Spring flowering marked *s;* summer flowering not marked; autumn, *a.*)

ANNUALS: Balsam, stock, petunia *a*, zinnia *a*, aster *a*, pansy, nasturtium, verbena *a*, poppy, California poppy, pink, phlox, salvia *a*, portulaca, candytuft, sweet alyssum, calendula *a*, castor bean, kochia *a* (mock cypress), marigold *a*.

BIENNIALS AND PERENNIALS: Hollyhock, phlox, larkspur, peony *s*, golden glow, tulip *s*, crocus *s*, hyacinth *s*, daffodil *s*, lily of the valley *s*, German iris *s*, day lily, Oriental poppy. The following must be taken up for the winter: Geranium, fuchsia, begonia, canna, dahlia *a*, gladiolus.

FOLIAGE BEDS: Castor bean, caladium, coleus.

PERENNIALS:

SPRING FLOWERING: Tulip, crocus, German iris, lily of the valley, bleeding-heart, columbine, peony.

SUMMER FLOWERING: Larkspur, phlox, golden glow, feverfew, Shasta daisy, white day lily, yellow day lily, grass lily, tiger lily, perennial poppy, clematis, honeysuckle, foxglove.

AUTUMN FLOWERING: Yucca, dahlia, wild aster, wild sunflower, wild cone flower, golden rod, blazing star.

Must be taken up for winter: Geranium, begonia, fuchsia, canna, dahlia.

VINES:

ANNUAL: Wild cucumber, morning-glory, scarlet-runner, canary-bird vine, nasturtium, sweet pea, ipomea.

BIENNIAL: Allegheny vine.

PERENNIAL: Clematis, virgin's-bower, hop, honeysuckle, wistaria, bittersweet, wild grape, woodbine, Boston ivy, green brier, moonseed, English ivy where hardy.

WILD FLOWER GARDEN:

(Those that grow in the shade marked *.)

SPRING FLOWERING: Dandelion, blood-root,* trillium,* spring beauty, bellwort,* violet,* columbine,* Jack-in-the-pulpit,* dog-tooth violet, Dutchmen's breeches,* wild phlox,* false Solomon's seal,* waterleaf,* lady's-slipper,* wind-flower,* hepatica,* pasque flower, fleabane, puccoon.

SUMMER FLOWERING: Pitcher plant,* red lily, virgin's bower, wild cucumber, daisy, aralia,* Solomon's seal,* yarrow, thimble anemone, catnip, horsemint, butterfly weed, milkweed, iris, harebell, bellflower, lobelia.

FALL FLOWERING: Wild sunflower, cone flower, compass plant, cup plant, aster,* goldenrod, blazing star, monkey flower,* eupatory,* mullein, evening primrose, fireweed (*epilobium*), hemp, butter-and-eggs.

PLANTS FOR WINDOW-BOXES AND POTS:

INDOOR:

SHADY WINDOWS: Mainly foliage plants—begonia, dracæna, palm, wandering Jew, asparagus "fern," true fern (Boston), vinca vine, English ivy, coleus.

SUNNY WINDOWS: Geranium, fuchsia, bulbs, salvia, pansy, chrysanthemum, sweet alyssum, primrose, azalea, carnation, marguerite, petunia, cineraria, palm, English ivy, asparagus "fern," heliotrope, smilax, Kenilworth ivy, feverfew, ageratum, coleus, vinca, umbrella plant, Boston fern, cactus, century plant, camellia, rose-scented geranium, bryophyllum, oxalis, India-rubber plant, abutilon, calla, Easter lily.

OUTSIDE: Only the more hardy of the above can be used for this purpose.

SHADY SIDE: As above.

SUNNY SIDE: Geranium, ageratum, feverfew, coleus, salvia, sweet alyssum, marguerite, petunia, palm, asparagus "fern," fuchsia, pansy, chrysanthemum, tulip, crocus, vinca, wandering Jew.

SHRUBS:

SPRING FLOWERING: Forsythia, lilac, snowball, syringa, flowering currant, hawthorn, rose (including wild), mock orange, mountain laurel, rhododendron, currant, raspberry, blackberry, gooseberry, barberry.

SUMMER FLOWERING: Bush honeysuckle, weigelia, privet, wild elder, rose, sumach, dogwood, spiræa.

FOR AUTUMN: Hydrangea, barberry in fruit, elder (red berried) in fruit, witch-hazel.

WINTER EVERGREENS: Juniper, holly, rhododendron, balsam fir.

CHAPTER XVII

LESSONS WITH PLANTS

THESE lessons are intended to acquaint the child with the life and nature of plants, with the conditions under which they grow, and with the functions of the various organs. The plants should be studied as living creatures, not merely as dead specimens. There is a practical side to this study, as it should teach the child how to cultivate plants.

Plant lessons are easy to give. Plants are clean and not repugnant. There is an element of beauty in the work that appeals to children, and this fact should be taken advantage of. There is an abundance of illustrative material, easily obtained, which changes with the seasons.

Many of these lessons should be given or applied in the school garden, where much material may be obtained. In fact, the garden should be a sort of botanical laboratory for this work. Therefore read the suggestions in the previous chapter.

Germination

It is a traditional custom in nearly all schools to plant seeds in the spring and to see them grow. Generally this is not very profitable as usually conducted. The planting of seeds and the observation of their development may be made to teach valuable lessons in gardening and the con-

ditions for plant life. Most people love flowers and would like to know how to raise them.

These germination lessons may be utilized to teach the children how to prepare the soil, the use of fertilizers, and the proper temperature and moisture conditions necessary for germination and growth. Older pupils should try some instructive experiments. Let them compare seedlings grown in cold and warm temperatures, with sufficient, too much,

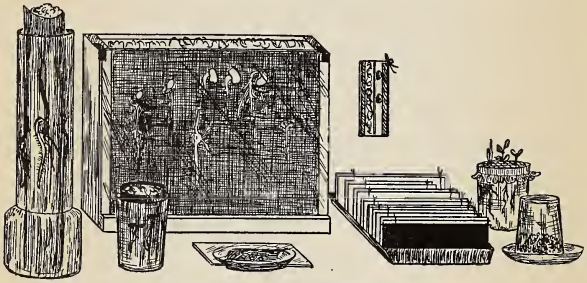


Fig. 106. Germinators for Observing Seeds and Seedlings.

and too little water; in fertile and sterile soil; in loam, sand, clay, and mixtures of these.

Most people are apt to plant seeds too deep. They can be buried so deep that the seedlings will fail to reach the surface.

Very small seed, such as petunia, should be lightly sprinkled over the surface of the soil and kept moist. Some very fine soil may be sifted over thinly. Larger seeds may be planted deeper, from three to four times their thickness. If started in boxes they will germinate better by keeping a pane of glass over the box till the seeds are up, when the glass should be removed. Be sure to get fresh seed.

Plant corn, wheat, peas, beans, sunflowers, squash, radish, etc. These germinate well, and the plants from them can be used for many observations and experiments on plant life and behavior. Also let the pupils sow flower seeds and raise plants that they will care to keep. In this way pretty window-boxes of flowers can be raised, or the seedlings may later be set out in beds. Let the pupils take home the plants started in school. Encourage the cultivation of a vegetable garden and flowers at home. Sweet alyssum, candytuft, portulaca, dwarf and climbing nasturtiums, phlox, pansies, pot-marigold, zinnias, and asters are excellent plants for the purpose. Morning-glories cannot be transplanted well, and should be raised where wanted. If the boys feel that flower culture is too effeminate for them, which is not the case, however, rouse their interest by getting them to plant vegetables, and plants like cotton, flax, tobacco, peanuts, and others not so commonly seen. Also let them plant the seeds of apples, plums, cherries, oranges, and lemons, and other fruit trees; of acorns, butternuts, walnuts, and other nuts; of elms, maples, basswood, pines, balsams, etc. These tree seedlings might be distributed to the children to plant at home. If they raise any of these to maturity they will always take a peculiar pride and interest in these trees. A cherry tree planted as a seed by a boy six years old will yield bushels of cherries by the time he is a man.

FIG. 107. An Oak Seedling.

The older children should make a simple dissection of the seed and learn the function of seed coats, seed leaves, rootlet, and bud. They should understand that seeds are young plants given a store of food as a start in life by the mother plant. They should compare the sprouting of different kinds of seeds, and note the interesting ways in which a seedling gets out of the seed coat.

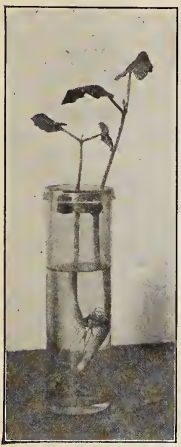


Fig. 108. An Experiment. One of the bean seedlings has its cotyledons removed and does not grow as fast as the other.

The germination of seeds can be very well seen in special vessels for the purpose, called germinators. A simple form consists of a deep and narrow box with glass sides. Fill with soil or sawdust and place the seeds close to the glass. Darken the sides with opaque paper. After a time the paper may be removed and the sprouting seeds may be seen. Another form consists of two sheets of glass, with cotton between them. A black paper or cloth over the cotton sets the seeds off well. Keep the cotton moist. A simple germinator is made of a tumbler treated in a similar manner. A very pretty way to show the germination of small seeds, such as radish, etc., is to place a piece of flannel or blotter in a saucer. Place the seeds upon this, and cover with a tumbler, slightly raised at one side to admit air. Keep the blotter moist and the seeds will soon show the cotyledons and the root, the latter all covered with a glistening fuzz of root-hairs by means of which the root absorbs moisture.

Plant Organs

The principal organs of a higher plant should be studied in order that children may get a general knowledge of the structure and functions of a plant, and that they may know how it lives. Only the gross structure need be studied in nature-study, but attention should not be confined to structure simply; the adaptations and the functions of the structure should also be taught.

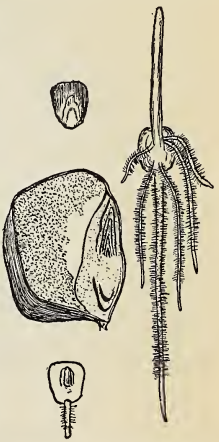


Fig. 109. Germinating Corn.

The root is the organ of absorption and anchors the plant firmly in the soil. The little root hairs that may be seen on seedlings germinated on a blotter are the essential organs in absorbing the soluble minerals and the water and organic matter from the soil. These root hairs should be examined with a microscope. They are seen then to be prolongations of the epidermal cells of the root. They are very delicate, and are torn off when a plant is pulled up from the ground and hence not seen.

Let the children dig up carefully different plants and note the extent of the root growth, the shape of the roots, and their branching. In a grain field pull up a hill of grain and note the root extent. Then dig a hole or trench and wash away the earth from the roots, exposing them carefully. The root extent is then found to be surprisingly great, extending to a depth of several feet instead of only five or six inches, as simply pulling up the plant would seem to in-

dicate. A similar experiment may be tried at a road-cut or hillside cutting, where the roots of plants may be exposed in the same way. Tree roots may be followed long distances where they have been exposed by erosion. This may help to give the children a better idea of the importance of roots. In a general way we may say that the root growth below the surface of the soil equals that of the stem and foliage above.

Try this experiment: Cut off close to the root the stem of a seedling like a squash or sunflower and note the sap flowing up from the root. This illustrates the power of roots to send up moisture.

Fleshy roots, such as the beet, turnip, carrot, and others are devices of the plant to tide over some unfavorable period of cold or drought. The first year the large cluster of leaves produces a store of food which is placed in the thick root. The next year the plant sends up rapidly a tall stem with flowers, and goes to seed. From this habit the plant is called a biennial. Sometimes some of these plants will complete their cycle in one season. Examine different fleshy roots. Refer to the supply of food in the root primarily intended for the plant itself, but which we make use of for ourselves.

Plant some turnips or carrots and see what they do. Note the softening and shrivelling of the root as the plant grows. Account for this. Dig out the core of a carrot or turnip without injuring the crown of buds at the top, so as to form a little bucket. Fill with water and hang up in the window; let it develop. Try one with the hole made in the other end and hung upside down.

Stems conduct the sap and hold the leaves and flowers up

to the light. Annual plants have soft or herbaceous stems. Perennial shrubs, vines, and trees have hard and woody stems. Compare them. Cut across a young, herbaceous stem like a cornstalk and note the thread-like strands that run through it. These may be shown better by cutting through the hard outer layer of the stalk and breaking and pulling apart the rest, when the strands will appear as threads projecting out from the stalk. These strands are found in all stems and are very important. They consist partly of strong cells that give rigidity and strength to the stem, and partly of duct-like or tubular cells that allow the sap to flow through them. These strands of strengthening and conducting tissues are called, technically, fibrovascular bundles, and serve as a sort of skeleton for the plant and as its circulatory system. Some ducts convey sap up, while others let it down to the root.

Fig. 110 Fibrovascular Strands in Plantain Leaf.

In plants that have two cotyledons or seed leaves in the seed, as for example, the pea, bean, sunflower, geranium, squash, box-elder, lilac, etc., the fibrovascular strands are arranged in a ring around a central pith. Cut across a young sunflower stem or young lilac shoot and this can be seen. Press the stem and see the water exude from certain parts of the ring. Here are the tubular conducting

ducts. Outside of the tubular part of the stem is the bark, not yet hard in young tree shoots and in herbaceous plants.

In cornstalks, lily stems, palm stems, and grasses, the strands are not thus arranged, but are found distributed throughout the pithy substance of the stem.

If we cut across a twig of a tree that has become woody,

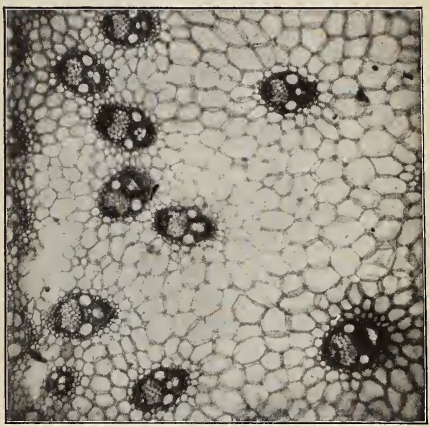


FIG. 111. Section of Corn Stalk Showing Fibrovascular Bundles. (Photomicrograph.)

we shall see that the woody part is distinct from the bark on the outside and a pithy portion at the centre. In the spring the bark can be easily peeled from the wood. This is because there is then a layer of especially thin-walled cells between them which can be easily torn. In making a whistle of willow or basswood, boys beat upon the bark to crush this layer of cells and thus loosen the bark. It is in this layer, called the growing zone, that the new growth in the thick-

ness of the stem takes place. Wood forms on the inside and new layers of bark on the outside. As the wood within gets larger, the old bark coat becomes too small and cracks into fissures or peels off in layers. This is seen in all old trees. In each species there is a characteristic mode of fissuring of the bark by which alone we are often enabled to distinguish the tree. The plum and the birch peel off around the stem. The soft maple bark splits off in long strips up and down the stem. In other trees the bark wears away less conspicuously, though just as truly.

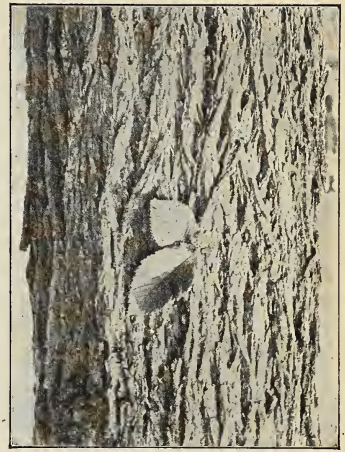


Fig. 112. The White Elm.

In sections of stems or twigs of more than one year's growth there is seen a concentric arrangement of the wood. This is called the annual rings, by which, as a rule, we can tell the age of the stem, one ring being formed each year. In the spring the cells of the new wood are thinner walled and larger than the cells formed in the later growth of the summer. Hence each spring's growth appears lighter and more porous than the growth formed in the preceding fall.

Bring in pieces of firewood or go to a sawed-off tree and determine the age by counting the rings.

Modified Stems for Propagation: After the typical

stem has been studied, modifications of stems should be considered, to show how an organ may become adapted for an entirely different function.

Strawberry runners are long, slender branches sent out above the ground by the plant, which radiate from it, striking root and sending up a cluster of leaves at the joints. In time, if left naturally, the connecting runner would die and decay away, thus leaving a number of separate plants that at one time were all one. This is a device for propagation. The gardener utilizes this artificially in obtaining new plants for setting out.

Fig. 113. The White Birch.

The long, drooping branches of currants, raspberries, and other plants touch the ground with the ends and strike root there, thereby starting another plant by a method similar to that employed by the strawberry.

Try some simple experiments in layering, slipping, and grafting. (See last chapter.)

Underground Stems: There are other peculiar modifications of stems for the purpose of propagation. Many plants have underground shoots and stems which help them to tide over a period of cold or dryness, or by which they

are multiplied. One of these is the root-stalk, so called because it looks like a root. Bloodroots, Solomon's-seal, many common grasses and other plants have such organs. In the first two mentioned cases, the true roots spring from a root-stalk which is thick with a supply of food. Common June grass and many other grasses have long, slender root-stalks.

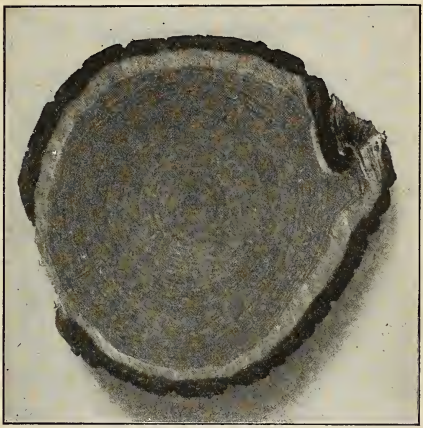


Fig. 114. Cross Section of White Elm Showing Bark, Sapwood, Heartwood, and Yearly Rings.

Pull up some June grass root-stalks, examine the joints, scales, and roots, and note the spears of grass rising from the joints. Cut the root-stalk into as many joints or sections as have rooted, and plant each to see if it will grow independently. By means of such stalks the grass spreads rapidly. Golden-rod and the cultivated goldenglow have fine root-stalks.

The Jack-in-the-pulpit has a short, rounded root-stalk, called a corm.

The onion and lily bulbs are also modified stems. Cut an onion through lengthwise, and note the thickened leaves that surround a kind of central bud, the whole forming a condensed leafy bud. The scales on the outside serve for protection, those within to store nourishment. Examine also tulip and amaryllis bulbs. Raise some hyacinth bulbs in water.

The potato is another sort of underground stem, a short

Fig. 115. Rootstalk of Solomon's Seal, a Storehouse of Food.

and rounded root-stalk. The eyes represent buds, each of which is capable of sprouting and forming a new plant. Cut a piece of potato containing only one eye, plant it, and raise a plant. Set a potato in a glass or can of water and note the shoots that arise from the eyes. The potato is composed mainly of water and starch. Show with the iodine test that it has starch. Show starch made from potato. Examine some starch grains under a microscope. This starch was made by the leaves of the plant and stored away

in the tubers or potatoes. We use this supply of starchy food intended primarily for the plant. Similarly other underground stems and bulbs are storehouses for food. This is generally used the next season in making a rapid growth. Most of our very early spring flowers are enabled to bloom so early because they have a supply of food ready. Dig up a number of the earliest spring flowers and this will be seen to be true.

Buds

One of the first signs of spring is the swelling of the pussy-willow's buds. They may be found in wet meadows and sloughs, in company with poplars and red osiers. Let the children bring some to school. Set the twigs in water and watch them develop. These pussies are flower buds.

A little later collect twigs of lilac, cottonwood, soft maple, boxelder, and horse-chestnut and place them in water. Let the children study the changes from day to day. First the buds swell, then the little brown, dry scales with which the buds are covered are pushed apart or entirely crowded off, and a little bundle of delicate leaves, or a flower cluster, or both, appear. In a few days more the leaf buds have elongated into short stems with the leaflets arranged alongside. From such a study it will be seen clearly that a leaf bud or a flower bud is a condensed or miniature stem with leaflets, packed away in the protecting scales. In the course of a season, the buds on young trees may grow to the length of several feet, though the growth is much less on the older trees.

Note the bud scales, their thickness, texture, stickiness, or hairiness. They serve to protect the buds from mechanical injury and prevent the drying out of the tender leaflets

within during the winter. Do not tell the pupils that the scales are warm, cozy blankets or jackets that prevent the freezing of the buds in winter, for that is not true. In weather 20 below zero or more these thin scales would be scant protection against freezing. Ask the children if they would want nothing more on in such weather. In fact the buds do freeze within. Providing the freezing, and especially the thawing out, proceed slowly, a frozen ear will not be permanently injured. Frozen apples and potatoes can be restored in good condition if thawed slowly, but if thawed rapidly become flabby and soon decay. It is somewhat the same with vegetation in winter. The artificial covering that we put over the pansy and strawberry beds in winter does not prevent the freezing of these plants, but it does prevent *sudden* freezing and thawing. The nonconducting litter over the plants permits these changes to take place only slowly. So also the scales on the buds are nonconductors and serve a similar purpose. The natural litter of leaves and grass protects many seeds, roots, and stems of plants in winter. Even the snow is a protective covering in this sense, preventing the killing of winter wheat and clover and many wild plants.

FIG. 116. Buds are Condensed Branches.
The two upper twigs show young branches that have come from buds as short as those on the two lower twigs. Lilac.

Note the position of the bud on the branch. Immediately below it we generally find a triangular scar or mark which shows where the last year's leaf has fallen off. This is called a leaf scar.

Remove the bud scales all around a large bud. Note the circle or girdle of scars that is produced thereby. This is called a girdle scar. A similar girdle forms naturally when a bud unfolds in spring and the scales drop off, and will be found at the very base of the shoot of that season. Begin at the tip of a twig and trace back till you come to such a girdle scar. The interval from the tip to the scar marks a year's growth. Trace farther down the twig and find perhaps other such scars. In this way the age of a twig or a tree may be told. The internodes between such scars are often quite long in young trees or shoots, but sometimes half an inch or less on the older parts of a tree.

Let the pupils gather different kinds of twigs and draw them.

FIG. 117. Cottonwood and Butternut Twigs. (To show buds and yearly growth.)

Leaves

Ask the pupils what leaves are for. Unless they have been taught they will probably answer that they do not know. Some may say, "To look pretty," "To give us shade." Much older people often can give no better

answers. Though we may find pleasure in the beauty of the foliage and enjoy its shade, this is not the reason why plants have leaves.

A plant breathes, perspires, makes its food, and also does other useful things with its leaves. Looked at in this way a leaf is a very important organ to a plant.

While the full meaning of a leaf cannot be made clear to grade pupils, yet its general function can be taught them by a few experiments.

Plants wilt because they lose water from their leaves. This is called transpiration. It may be very easily shown by cutting from a geranium or other plant some leaves, covering the cut end with vaseline or wax so as to prevent the escape of moisture through these ends, and placing the leaves under a tumbler in the sunlight or other warm place. In a short time drops of moisture given off by the leaf will be collecting on the inside of the glass.

This water must come out of the leaf elsewhere than from the cut ends. It is exhaled as vapor from minute openings, called breathing pores, in the skin or epidermis of the leaf. These pores are visible readily under a compound microscope; and on the leaves of the Wandering Jew they are visible with a simple magnifying glass. On the common liverwort, *marchantia*, though not a leafy plant, the breathing pores are visible easily to the unaided eye. If specimens like these can be got, the pores should be shown. At any rate, diagrams should be made giving a leaf in cross section, to show the loose, spongy tissue of green cells within the leaf, the conducting strands (veins), and the breathing pores. Show also surface views of the pores. Through these pores the moisture escapes, and when

a plant cannot supply itself rapidly enough with fresh water from the roots it wilts.

Place a cherry, maple, or other leafy twig in a bottle of water. Note the height of the water. Close the mouth of the bottle to prevent evaporation. Note the rate at which the twig absorbs the water and the leaves give it off to the air.

This current of water flowing through the plant is neces-

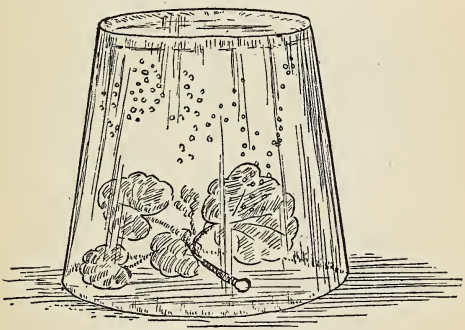


Fig. 118. Transpiration.

sary, in order that fresh mineral matter may be brought in from the soil for the nourishment of the plant.

Leaves are green. Why? Bring in some celery stalks, or some potato or carrot sprouts that have grown in the cellar in the dark. Note their blanched condition. Lay a board a few days upon the green grass, and on removal note the yellowish or bleached place left by the board. Note that the grass turns green again in the sunlight. Place some of the cellar-grown sprouts in the sunlight to grow. Note the greenish color that appears after several days. Sunlight

is thus seen to be a condition necessary for the formation of the green color of plants.

This green color is not due to a green liquid in the cells of the plant, but to little green grains called chlorophyll—leaf-green. These may be seen nicely in moss-leaves under the compound microscope.

Make a little paste, in water, of cornstarch or wheat flour, and add a few drops of a solution of iodine with a little potassium iodide added, or of a tincture of iodine. On the application of this solution the starch of the cornstarch and flour turns deep blue. This is a test for starch. Test for starch in a kernel of corn, in a grain of wheat, or in a potato.

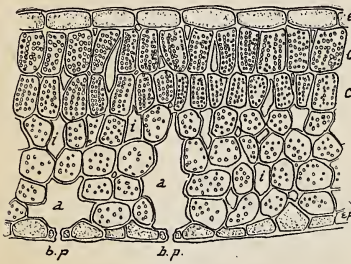


FIG. 119. Diagram of a Section of a Green Leaf.
ep., epidermis; *c.*, cells with chlorophyll grains; *i.*, intercellular spaces; *a.*, air chambers; *b. p.*, breathing pores.

Now get some variegated leaves, such as those of the white-bordered geranium. Boil a few minutes in water, and then soak in strong alcohol for several minutes. This dissolves out the chlorophyll. The solution with the alcohol may have to be repeated before the leaf is quite bleached. Now place the leaf in the solution of iodine and potassium iodide. The part that was green before will now turn blue, while the former white border will remain so. This proves that the starch was formed only in the green part of the leaf. Starch forms where there is chlorophyll, and as a rule not elsewhere.

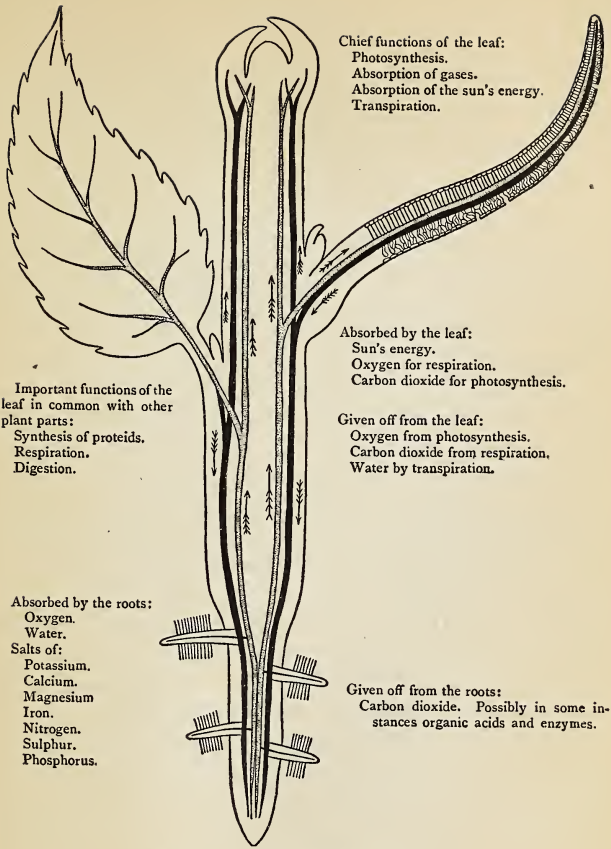


FIG. 120. Longitudinal Diagram of a Plant.

In this diagram the dotted highway is the water conducting area, and the black highway is the area for conduction of the food made in the leaf. The arrows indicate the direction of flow in these highways. From Steven's "Introduction to Botany," copyright, 1902, by D. C. Heath & Company. Used by permission.

To show that light is necessary for starch formation, and that the chlorophyll alone is not sufficient, place a geranium or nasturtium in a dark room or in a light-tight box for a day or so. Then test as before and no starch will be found in the leaves.

These experiments show that starch is formed in the green parts of plants, and in the presence of sunlight. This shows the great importance of sunlight to plants. Why do we place house-plants in the window? Plants like geraniums placed in dark or shady places would be in a starving condition. Explain.

The leaf absorbs carbonic acid gas from the air, and water is brought to it from the root. Out of these substances the leaf cells make the starch. The leaf, therefore, is a very important organ to the plant. The explanation of starch formation as it takes place in the leaf need not be given in the grades. Let it be sufficient to show that the leaf does make starch. A figurative explanation may, however, be given in this manner: "The leaf is a mill where the raw materials taken in by the plant are ground and prepared. The raw materials are water and carbon dioxide. The millstones are the chlorophyll grains, and the power that turns them is the sunlight." The figure is very apt.

The starch is used by the plant as food, and is readily converted into sugar, and vice versa. Thus we have the sugar in sugar cane and fruit. By the addition of the mineral salts (nitrates, potash, lime salts, phosphates, etc.) taken in by the roots, other food substances (proteids) are made by the plant.

Sometimes the food is not all used up immediately by the plant but is stored for a time as a reserve. Thus we find

starch in tubers, roots, root-stalks, and other parts as a reserve supply. Seeds also contain reserve food, sometimes in the form of starch as in grains, sometimes in the form of oils as in many nuts, and in other forms. It is chiefly in this form that man utilizes the food obtained from plants.

As a by-product in starch-making, plants give off oxygen gas. They absorb for their food the carbon dioxide which is harmful to animals, and return to the air the oxygen which the latter need. Animals, on the other hand, in breathing give off carbon dioxide.

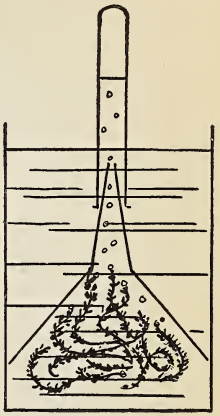


Fig. 121. Giving off Oxygen.

The oxygen given off by plants during starch-making may be shown by the following pretty experiment:

Collect a mass of green pond scum or other water plants. Place in an aquarium in a sunny window. Set a glass funnel over the plants in the water, and over the tube of the funnel slip an inverted test-tube filled with water. Let stand several days and note that the bubbles of gas given off from the green plants rise into the test-tube. After a considerable quantity has collected, the tube may be removed carefully, closing the opening with the thumb to prevent the escape of the gas. Then with a glowing taper the gas may be tested. If the taper bursts into a flame when it is thrust into the test-tube the gas is oxygen.

The above experiments on the function of a leaf may be performed in any of the grammar grades; even in the sixth

grade of the intermediate the children will appreciate much of their meaning. In the primary grades also a little can be done to show the children the necessity of leaves to the plant, and the need of sunshine to make it grow. Cut off the leaves as they appear on a plant and note the effect on the growth. Place a plant in the dark for several weeks, and note then its sickly, spindling condition. Plants need sunshine as much as little children.

Primary children may also collect leaves of different forms, study their shapes and venation, and make drawings of them. In the autumn let them gather colored leaves and paint them.

The relation of plants to light is seen also in their attempt to arrange their branches and leaves so as to give all an equal chance at the light. Go out on the school lawn and note the beautiful arrangement of the leaves of a dandelion or common plantain. They are arranged in rosettes. Examine the twigs of maple, horse-chestnut, and other trees, and you will see that in general they grow so that they do not shade each other. Go into the forest or a thick grove and note how on account of the lack of light the lower branches of the trees are weak and dying. Note that plants which have plenty of light do not grow so tall and slender as those that grow in the shade. In the shade, plants grow tall in trying to reach up to the light. This is also seen in trees. Compare a maple or pine that has grown in the open with one grown in a dense forest where it was shaded by its neighbors.

Modified Leaves: Sometimes the leaves of plants are modified for secondary functions. For example, the pitcher plants have curious hollow leaves that generally contain some water into which insects fall and drown. The plant

absorbs the solution of their decayed bodies. These plants grow in tamarack swamps. Dig up some of them, plant in a pot, and grow in the school. They are very pretty and interesting.

The sweet pea, common peas, and vetches have the midrib of the leaves modified into long tendrils that are sensitive to touch. When they reach a support they curl around it and hold the plant up. The common thistle has its leaves covered with spines. A similar thing is seen in many other plants, notably in the Russian "thistle." Bud scales are also modified leaves, serving a special protective purpose. The bud scales on the lilac become true leaves.

Leaves sometimes function as storehouses of food. This is seen in the thickened bases of the leaves of an onion.

The older children can understand that the flower parts, the floral envelopes, and even the stamens and pistils are simply modified leaves. Occasionally "green" flowers appear on roses and other plants, which show plainly the reversion of some floral structure to the green leaf-like state. The calyx generally retains its green and leafy appearance.

The Flower

The flower is the most beautiful and wonderful organ of a plant. It is also very important in that through it the plant reproduces itself. The flower should be regarded as the seed maker. Generally it is simply thought of as something fragrant and beautiful, and the other fact is lost sight of. A child cannot get the full meaning of the complex process of seed formation, but he can and should know in a general way what a flower is for.

One of the earliest spring flowers is the Dwarf Trillium

growing in rich moist woods. Pull the plants up by the roots and observe that they spring from a rounded, bud-like rootstalk. This was formed last summer and filled with a store of food that the plant might make an early start in the spring. There are three large leaves in a circle around the stem just below the flower. These will have to make the starch with which next year's rootstalk is to be filled.

Fig. 122. Wake Robin or Dwarf Trillium.

Look at the flower. On the under side and surrounding it are three green, leaf-like parts. These are the sepals. Taken together they are called the calyx, which means cup. This cup-like appearance of the calyx is seen better in some other flowers, as, for example, in the morning-glory. Next within are three white parts, shaped like the sepals. These are called the petals, and all together they form the corolla, meaning crown. The corolla is more crown-like and golden in some other flowers, as, for example, the buttercup. In-

side the corolla are six knobbed stalks with yellow heads. These are the stamens, and the knobs on the top are anthers. The anthers are split open along the sides and a yellow powder may be seen crumbling out. This powder is called pollen and consists of minute grains. Bees like to eat it and carry it away to their hives. In the centre of the flower is

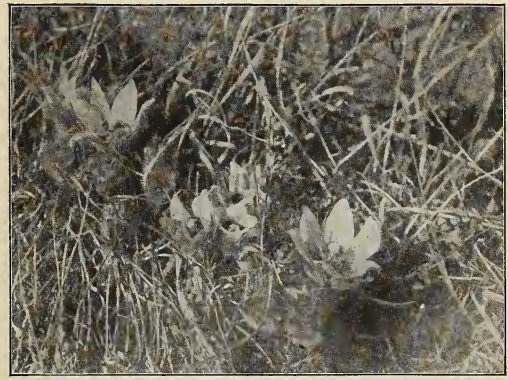


Fig 123. The Pasque Flower or Hairy Anemone.
(One of the very earliest.)

still another structure, shaped like an angled cone, greenish in color, and with three little projections on top. The whole thing is called the pistil. The swollen lower part is the ovary, and the slender projections on top are called stigmas. The ovary contains the rudimentary seeds. If it is cut across the middle the ovules or young seeds will be seen in three cavities. These ovules will not develop into seeds unless the pollen from this or some other trillium flower falls upon the stigma of this pistil. Pollen is an essential thing

in seed formation. When the flower goes to seed the pretty corolla fades and withers, and the stamens also fall off. The ovary grows larger and changes into a fleshy red fruit that contains the ripe seeds.

Make a large diagram on the black-board to show the flower plan. Also make enlarged views of the stamens, pistil, and section of the ovary. Let the children draw similar diagrams after a study of the flower.

Dig up a lot of budding-plants and plant them in a dish. They will open in the school-room and make a pretty display.

The above is a suggestion for the method of studying a plant in general, and a typical flower in particular. After a typical, perfect flower has been studied take up modified, irregular, and imperfect flowers. These should be studied with reference always to their peculiar adaptations. In many flowers the sepals grow together, and the petals unite to form a tubular corolla. In many the number of stamens is either increased or reduced, and their shapes vary much. There may be only one or several pistils in a flower. Sometimes they may unite into a single compound pistil, though the number that united may generally still be seen by outside grooves or by cutting across the ovary and counting the cells or cavities. The stigmas vary greatly in appearance. Sometimes they are borne at the ends of long slender stems called styles. In many flowers the sepals or petals are irregular or unsymmetrical in shape. These modifications are generally an adaptation to compel visiting insects to enter the flower in a certain way, and thereby come in contact with the stamens and pistils, bringing about cross-pollination, considered below. Sometimes either the calyx

or the corolla, or both, are missing. Sometimes flowers have stamens and no pistils and vice versa. This also is a device for cross-pollination. Types of flowers illustrating these modifications in structure should be shown.

Let primary children study flowers chiefly with an æsthetic interest. Teach them to recognize the parts of a perfect

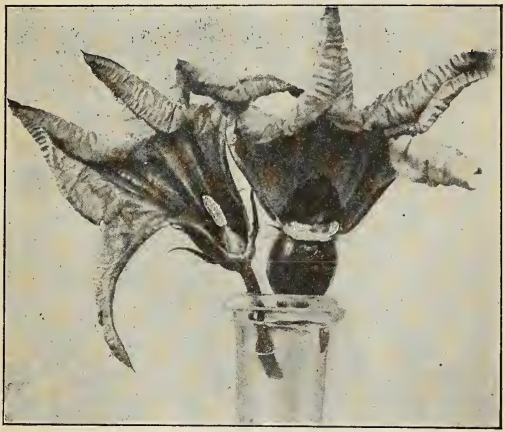


FIG. 124. Staminate and Pistillate Flowers of a Squash Cut Open.

flower. Also let them watch window or outdoor plants and see that the flower goes to seed. The process of pollination may be briefly studied. Watch the bees and other insects crawling in the flowers and see how they become dusted with pollen. Let the pupils begin to identify the common wild flowers.

In intermediate grades other points may be taken up. Study the floral organs more in detail, particularly the stamens

and pistils. The children should now be taught the meaning of the perfume, nectar, and beautiful colors. These are not meant for us but primarily for the benefit of the plant. They attract the passing bees, butterflies, and other insects. The colors and odors are simply conspicuous signs that here is insect refreshment to be had. The insects in exchange, though unconsciously and unintentionally, of course, pay therefor by carrying pollen from flower to flower. Though there were no human beings to appreciate its beauty and fragrance, still full many a flower would not be born to blush unseen and waste its sweetness upon the desert air, if it did attract insects that would cause cross-pollination. Let the children examine more closely the way insects enter flowers and how they carry the pollen to other flowers. Consider a few

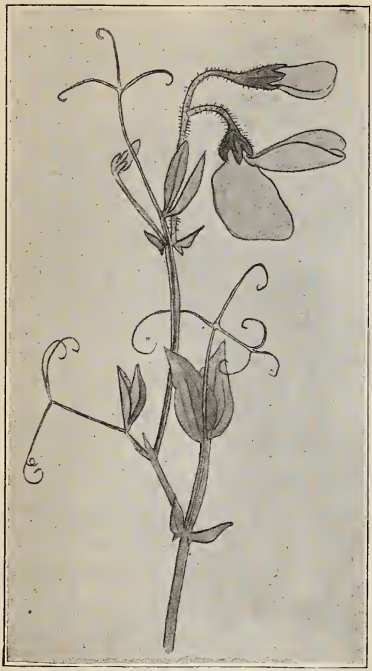


Fig. 125. Sweet Pea.

simple cases of cross-pollination, such as the sweet pea, the morning-glory, sweet clover, etc. Try this experiment: Tie over a sweet pea bud or a red clover head a paper or muslin bag. The flower so treated will not form seeds. In many flowers there is provision, however, for the pollen to come in contact with the stigma of the same flower. Self-pollination thus takes place and seeds will form. A better experiment is this: Select some flowers that have pistillate and staminate flowers separate, where self-pollination is impossible. The squash, pumpkin or cucumber is very good for this. Cover the pistillate flower so insects cannot get at the stigmas, and no seeds or fruit will form. This will bring out well the importance of the stamens and pistil and also of the process of pollination. Refer to the subject of cross-pollination as treated under Insects, page 224.

FIG. 126. Pollination in Sweet Pea.

In these grades also a simple study may be made of another method of pollination, namely, by the wind. Get the pendulous catkins of cottonwood and butternut, the staminate

catkins of pines, or the drooping staminate flower clusters of the boxelder or hard maple. If they are not quite ripe place them in water for a few days. Then the anthers will be open and the slightest jarring of the branches will shake out great clouds of fine, yellow pollen which floats upon the air. Make a study in a general way of these plants, noting

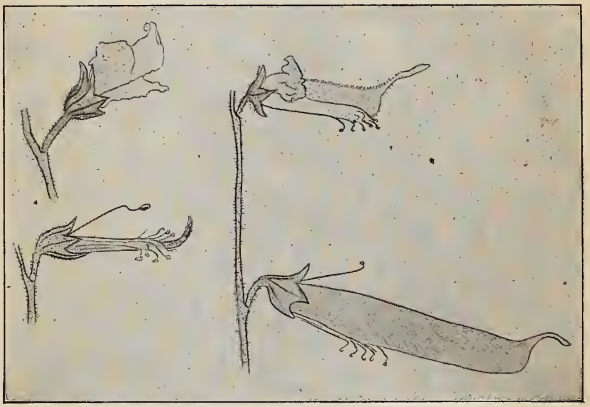


Fig. 127. Development of Sweet Pea Flower into Fruit.

the way pollination is brought about. As a rule these flowers are not pretty, yet very interesting on close examination. The study of the details of structure of these flowers may be deferred to higher grades. But here the fact should be recognized that these peculiar flower clusters produce an abundance of very light and dry pollen which the wind can shake out and carry away. Note also the large and often hairy stigmas of the pistil, and see how well they are adapted for catching the pollen as it drifts by.

Later in the summer, grasses should be studied. It will be seen that here also the wind is the chief agent in pollination.

Have the children realize that trees, grasses, and weeds are also "flowers."

In grammar grades still more may be done with the study of flowers and pollination. Peculiar modifications of flower structure to ensure cross-pollination should be considered, such as the lady's-slipper, Jack-in-the-pulpit, and other flowers. Here we can refer to the purpose of cross-pollination; namely, that by it rather than by self-pollination larger and better seed, and consequently better and stronger offspring, are produced. Most plants seem to try to effect cross-pollination, while many, like the plants that have only stamens or only pistils in a flower, make self-pollination impossible.

FIG. 128. Pistillate and Staminate Flowers from Separate Boxelder Trees.

Let the pupils try some experiments in pollinating flowers by hand. With a small water-color brush or a feather take off some pollen from a flower and transfer it to another flower of the same kind. Pollinate in this way differently colored varieties

of geraniums, sweet peas, pansies, tomatoes, corn, etc. In this way seed will be formed which, if properly ripened, will produce plants that have the combined or blended characteristics of the parents. This is called making hybrids. Many choice flowers in greenhouses and gardens and new varieties of fruit are thus formed by the cross-pollination of nearly related, but different, plants.

FIG. 129. Jack-in-the-pulpit.

These pupils are old enough to make a study of the unisexual flowers of trees. Begin with the willows and cottonwoods. These come out early in the spring before the leaves appear. The flowers are quite small, and are arranged in long drooping clusters, which are called catkins. On some trees there are only staminate catkins, and on others only pistillate. The staminate flowers consist each of a little scale, under which are borne a number of short stamens. At first the scales are closely overlapping, but as the flowers mature the scales separate, and the stamens with their dust-like pollen appear. This is wafted to the pistillate flowers on other trees. The pistillate flowers similarly consist of

a scale and large pistil. These flowers, compared with a flower like a rose, are very incomplete, yet they have the essential things necessary for seed making. The pistillate catkins become long clusters of green berry-like fruit. Later in summer the pods ripen, become papery in texture, and finally split open, letting out a mass of down-covered seed which floats away.

FIG. 130 Staminate Catkins of Cottonwood. (Pollen carried by wind.)

Compare with these the flowers of trees like the butternuts, walnuts, and oaks. These have staminate flowers very similar to those of the willows and cottonwoods, but in these the pistillate flowers are not in catkins, but are in clusters of a few or singly, and nearly sessile on the twig. They are, however, rudimentary in structure and do not possess a corolla or stamens. The acorns (ripe ovaries) are set in a scaly cup. Some acorns, like those of the red oak, require two years for ripening. Hence we find on the fruiting branches pistillate flowers and also year-old acorns, but on wood of different years.

Study the flowers of boxelders. These are not in catkins but in clusters and drooping masses, each floweret on a sep-

arate peduncle. The pistillate flowers have on the ovary curious expansions, which later develop into large wings for aiding in the distribution of the fruit.

The flowers of many other trees are worthy of study. Many are really very pretty when closely examined. Elm, ash, birch, basswood, and the conifers are all generally disregarded in nature-study, but should not be neglected. Pupils are else apt to forget that trees with such inconspicuous flowers are true flowering plants. Of course, such trees as have large, showy flowers will be studied anyway, as the apple, plum, cherry, hawthorn, locust, horse-chestnut, etc.

FIG. 131. Pistillate Flowers of Cottonwood.

In the autumn wild asters, wild sunflowers, coneflowers, coreopsis, golden rods, blazing stars, eupatories, thistles, and still some belated dandelions are in bloom. They constitute the chief glory of the early autumn in the fields, meadows, waysides, and wood clearings. In our gardens we have at this time cultivated asters, zinnias, dahlias, bachelor's-buttons, marguerites, daisies, gaillardias, cosmos, calliopsis, and marigold. The golden-glows and common tall sunflowers have probably gone to seed. All these plants belong to a great family called the Composites, which the pupils of the upper grades should not only learn

to recognize but understand the structure of in a general way.

The common sunflower is perhaps the best for teaching the structure of composites. A few belated specimens may still be found in the fall when school begins. But the single garden zinnias, and single asters, the wild sunflowers, and the daisies will do very well. At first thought one would think that what is generally called a sun "flower" is really a single flower, but closer examination will reveal the fact that this is an aggregation of hundreds of very small flowers massed together in a flat head. Note first the green calyx-like leafy scales on the outside of the whole. This is not a true calyx, but is called an involucre. Note how the scales are in several overlapping rows. Next within the green involucre comes a circle of flat, ribbon or strap-shaped, colored parts that are often wrongly called petals. They are not petals, but whole flowers. Pull out some of these flowers. Note that the flat

FIG. 132. Pussy-willows.
(The pussies are flower buds.)

band is rolled up and grown together at the lower end into a little tube. In fact, the band may be considered a little tubular corolla like the morning-glory slit open on one side nearly to the base. In the sunflower and many other such composites these outer strap-shaped, or ray, flowers, as they are called, are merely for show, as they have neither pistil nor stamens, and therefore do not form seed. But in the daisy, zinnia, and many other flowers they are not sterile, but form seeds. In the central part of the head are other flowers, small and tubular, with both stamens and pistils which produce seeds. Note the two branched stigma projecting from the centre of the little flower. Tear the corolla open and note the circle of brown or yellow stamens surrounding the style. The stamens open on the inside, and the style pushes out the pollen as it grows out of the corolla; but it is not self-fertilized thereby because it is not yet ripe or ready for pollination.

FIG. 133. Sunflower.
(Not a single flower, but a head or cluster of many small flowers.)

The "flowers" of the sunflower, aster, daisy, and other similar *compositæ* are thus seen to be composed of a large

number of small flowers closely grouped together in a flat head. On account of this structure the head is called a composite flower. This grouping is a device to make more of a show than if the little flowers were scattered separately

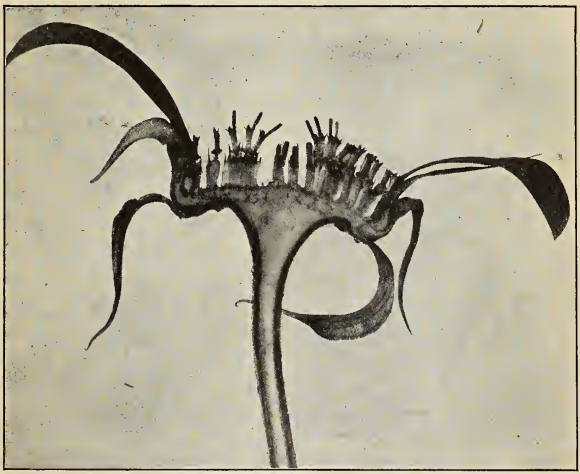


FIG. 134.

A section of a sunflower showing involucre bracts, rayflowers, and small tubular flowers standing on the flat receptacle. The central flowers are still closed. Then come several showing stamens, and the outer ones have gone to seed.

over the plants. Thus insects are more apt to be drawn to them.

The above named composites have two sorts of flowers, the ray flowers at the margin and a centre of tubular flowers. But there are modifications of this type. Some composites, like the dandelion and double aster, chrysanthemum, daisy, and zinnia, have only strap-shaped flowers throughout the

head. On the other hand, the thistle and bachelor's-button have only the tubular flowers. Compare these with the sunflower.

The dandelion and the thistle and other composites have hit upon a very ingenious device for scattering the seed, that is, by producing silken parachutes attached to the seed. Examine a dandelion or thistle head gone to seed. Blow off the downy mass from the dandelion and see how the "seeds" float away in the air by means of the little umbrella-shaped parachute.

Fig 135. Thistle.

Go out into the fields and roadsides and into the flower gardens with the class and pick out the composites. Also note such as have the parachute device for scattering the fruit. Some, like the beggar's-ticks (pitchforks), form spurs at the top of the fruits, with which they stick to the clothes of man or the fur of animals. Note the bees and butterflies at work pollinating the composites.

Studying the Common Flowering Plants

There is a peculiar pleasure in roaming about the fields and woods searching for wild flowers. Who does not delight at the sight of the first anemone or bloodroot in spring? To find a pink lady's-slipper or the Indian-pipe gives one

the feeling of the discoverer of a rare treasure. This pleasure in plants increases as our knowledge of, and familiarity with, them grow; most people know the names and habits of but very few plants. If a systematic study were made of our common, wild, flowering plants in our schools this would not be the case. Suppose the pupils were required to learn the names of, say, ten new plants each year, then by the time they passed through the eight grades of the common school they would know at least eighty plants, and this number could be easily increased.

In the lower grades it is stimulating to observation to have a flower calendar in the spring. This should give the dates when the flowers open and where they are found, that is, in what kind of places. Go out with the children and study the flowers where they grow, and gather some for indoor study of the structure. The children should learn to associate each plant with the habitat or kind of place in which it lives.

The chief purpose of the study of the common flowers is to be able to identify them. But many other general lessons may be taught with them, as to the function of typical organs and their modifications, as to the adaptation of the plant to its habitat or its mode of life, as to methods of pollination and the adaptation of plants to insects, also the means of seed dispersal, and the uses or harmfulness of the plant. Let these points be kept in mind in the study of each plant. It is not at all necessary that each point should be discussed with every new plant, but any notable characteristic in these respects should be observed and discussed. In this way the children will get much more than simply the name of the plant; they will learn a good deal about plant life in general.

Use pictures and black-board diagrams to illustrate the structure. In the upper grades a magnifying glass should be employed, and occasionally the compound microscope may be used to good advantage. There should be plenty of material for illustration. The whole plant, root and all, should be brought in. In case the plant is rather rare and is one of our choice wild flowers, it would not be right to gather too many specimens or to destroy the root.

There has been a good deal of harm done in the name of science. In the more densely settled regions of our country, in the neighborhood of cities, our native wild flowers are suffering great destruction. Much of this is due, no doubt, to the collecting of plants for school study and for herbaria. In a course of nature-study it is not necessary to press plants, unless it be for a school herbarium. The wild flowers should not be ruthlessly destroyed.

In studying "flowers" do not limit yourself to the conspicuously colored and showy kinds, but include others equally wonderful and instructive, such as trees, grasses, and weeds. Many people make a distinction between these and "flowers." But all of them are flowering plants.

Again, do not forget to study the late summer and autumn flowers, mainly composed of the composites.

Movements of Plants

Plants are so much regarded as passive things that it is well to show that they are fairly active and can actually move. The larger and higher types, of course, cannot move from place to place, but that is precisely what many microscopic plants can do. In the higher grades a drop of water containing some diatoms, found in the sediment of brooks and

ditches, may be shown with the compound miscroscope. These little unicellular plants have the power of locomotion. On moist earth in ditches there is often a coating of bluish-green algæ, the *Oscillatoria*, which also have some power of movement. There are spore-cells set free by many plants that swim actively about, and are reproductive devices.

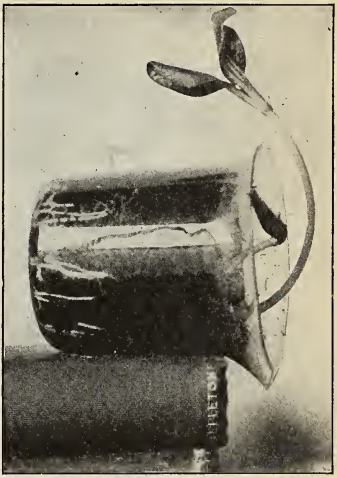


Fig. 136. Squash Seedling Laid on its Side has Straightened up Again.

Though the larger plants may not move about, yet they can move their various parts. A few observations on growing plants will show them to be thoroughly alive and active.

In a glass germinator (see p. 300) notice how the roots of seedlings grow down. Invert the germinator. Note that in a day or so the roots have turned and now grow downward again. They seem to know enough to grow down.

Note also how a rootlet bends away from and around an obstruction, such as a pebble placed in its course. The root is sensitive to touch and responds by a curvature.

Plant a sunflower or other seedling in the drain hole of a small flowerpot full of earth and hang it up somewhere. Note that soon the stem curves upward. The same may be shown

by simply laying a pot of young plants on its side. Grain that has been blown down or lodged in the fields will often, if not too ripe, grow upward again.

Plants generally turn toward the light. Set a box of seedlings in the window. In a very short time, if the light is strong, the plants will all be bending toward the light. Turn

Fig. 137. Plants Turning Toward the Light.
(Squash seedlings.)

the box around and see how long it is before the plants have again bent toward the light.

Most plants hold their leaves toward the light and tend to grow in that direction. Notice this in the geraniums, nasturtiums, and other window plants. Why do people turn their window plants around occasionally?

The sunflower has apparently a special fondness for the sun. Observe the top of a young plant outdoors at different times in the day, and see how the head follows the sun in its course.

Visit the edge of a grove or forest. Note how the outer

trees lean toward the lighter side. This is an effect of one-sided illumination.

Many plants assume definite attitudes during the night, as if they went to sleep. Note the position of the leaves of a young bean exposed to the light. Compare with another kept in the dark for a number of hours. In the dark the leaflets are more or less folded down and together and held closer to the stem. The oxalis, sweet clover, and other plants have similar habits.

Many flowers open and shut under the influence of light and darkness. We all know that the morning-glory opens early in the morning. The dandelion "wakens with the dawn." The four-o'clock remains shut until late in the afternoon.

The opening and closing of flowers may be partly due to the light and darkness, but not entirely so. Some plants seem to be regulated by the time of flight of the insects depended upon for pollination. Some flowers that open only at night are pollinated by moths and other nocturnal insects.

Instead of closing at night, many flowers simply droop or nod, and they do this also in the daytime to keep out the rain.

Some plants are excellent climbers. Some, like the peas, hold themselves to their support by means of tendrils. These are sensitive to the touch, and when they feel the support as they wave around in the air in search for it, will quickly curl around it. Other interesting tendrils are those of the wild cucumber and of the Virginia creeper or woodbine. One variety of the woodbine, the "self-clinging" kind, has tendrils that, as soon as they touch the support, spread out at the tip into little sucker disks that attach

themselves firmly. The climbing nasturtium has no tendrils, but its long leaf-stalks twist themselves about the support and hold up the plant.

Fig. 138. Morning-glory.

The morning-glory, the hop, and other twining plants should be observed as they climb on their supports. A young morning-glory may be seen to apparently feel around for something to climb upon. When it touches such a support, as it swings around with its tip, it seems to feel, and then grows spirally around the same.

The extreme of sensitiveness in plants may be seen in the plant very properly called the sensitive plant. This may be obtained at the greenhouses, or raised from the seed. Slightly touching one of the leaflets will cause it and the other leaflets in the compound leaf to fold together against the midrib. By greater agitation the whole plant may be made to fold up.

Plant Distribution and Seed Dispersal

Plants have their wanderings and migrations just as the races of men. That many plants produce motile spores, and that some algæ have the power of locomotion, has been mentioned. But the higher plants, though they may remain fixed as individuals, still make extensive wanderings as a race or species.

The races of man have become distributed over nearly

the whole earth. This migration may have been due to circumstances, such as the unfavorable conditions of life in the old home, the encroachment of more powerful neighboring races, or the attraction of a region affording better living, more freedom, etc. In many communities the con-

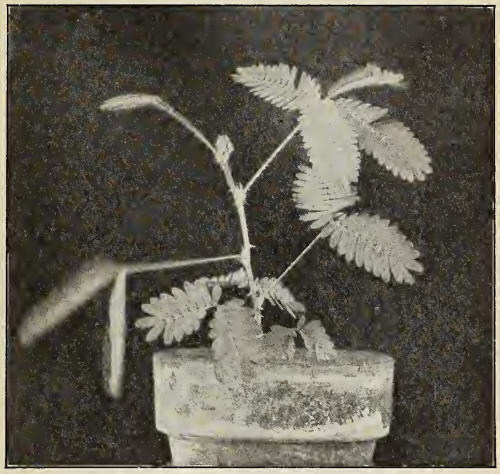


FIG. 139. Sensitive Plant.
(The leaf at the left was touched and was slowly closing during the exposure of the negative. Hence the blurring.)

ditions for making a living become intolerable or very difficult. Then the younger generations go to "pastures new." Many of them are assisted by their parents financially and by education to make this change. Generally the old people cannot leave their homes and finally die there. Thus a stock of people may die out in one place and appear again in another.

Much the same thing is seen in plants. There is a migration of species which is accomplished in many interesting ways. Generally the parent plants give their children a good "send off" and a travelling equipment that enables them to make the journey. Many provide also a

Fig. 140. A Neglected Corner is a Good Place for the Study of Seed Dispersal.

store of food upon which the young plant may make a start in life.

A simple way of distribution is by the formation of runners, suckers, stolons, rootstalks, tubers, bulbs, and roots. These have already been referred to as means for propagation.

Many of the lower plants multiply and are distributed by what are called spores. These are small cells set free, often in very great numbers, which float in the air or actually swim in the water. Bacteria, algæ, fungi, seaweeds, mosses,

and ferns possess spores. Being so small and light, spores float great distances with the wind, and it is thus that the

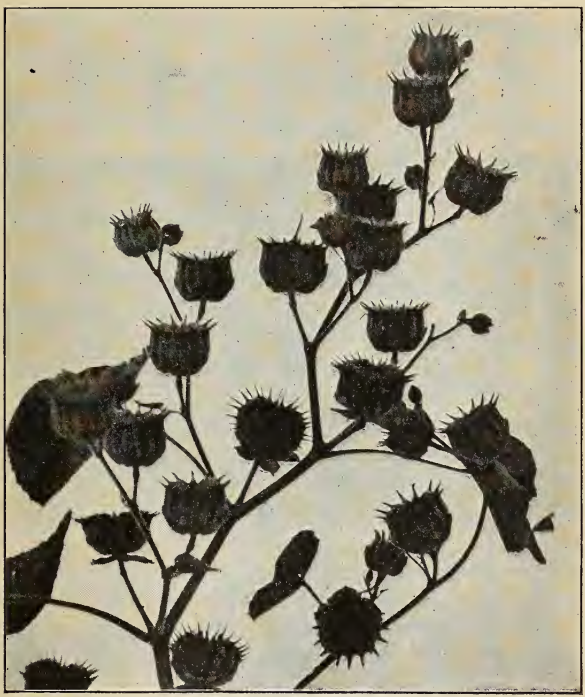


Fig. 141. Pretty Seed Pods.
("Butterprint" weed.)

germs of disease, of decay, of fermentation, the mosses and lichens, the fungi, and the ferns are so widely scattered.

Of greater interest are the devices for seed dispersal. The

simplest treatment of the seed by the parent is to let it fall upon the ground and trust that it will roll away or be blown or washed farther. But in this way the young plants are apt to come up too thickly at the base of the parent plant and thus choke each other. Some plants, however, have pods or capsules arranged in such a manner that the seeds cannot drop out directly, but are cast out to some distance

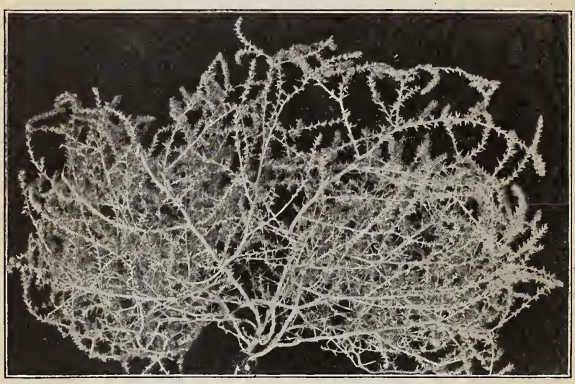


Fig. 142. Russian "Thistle"—A Tumble Weed.

by the swaying of the elastic stem of the plant. This is seen in the garden pinks and poppies.

The wind is the chief agency in seed dispersal for a great variety of plants. The Russian "thistle," the tumbleweed, and others break off as a whole close to the root and are carried by the wind over the hills and plains, scattering hundreds of seeds at every bound. This mode of dispersal accounts for the rapid spread of the Russian thistle since its introduction into this country a few years ago. Examine

a ripe Russian thistle and note how it rolls before the wind. Note the numerous seeds in the axils of the leaves.

The tickle grass (panic grass, old witch's broom) breaks off its feathery heads, which are carried away by the breezes.

In many plants the fruit is provided with special flying or soaring devices. This is well seen in our basswood, elm, boxelder, maples, ash, and in parsley and dock. Throw into

Fig. 143. The Wing Fruit of the Elm.

the air some of these fruits and see how easily they sail. Some, like the maple and basswood fruits, spin while drifting through the air. This helps to sustain them longer.

Some plants, like the clovers, the hop, blue beach, ironwood, and bladder-nut, have a bladdery envelope around their fruit as a sailing device.

But perhaps the prettiest and neatest arrangement for sailing is found in the down of many composite plants. The common dandelion, asters, goldenrods, and thistles have

beautiful downy parachutes, which are extensions and modifications of the calyx of the little separate flowers. The calyx in its free upper portion is split up into fine fibres that constitute the parachute. This carries away more than a seed. It is a seed plus a close fitting ovary and surrounding calyx. Hence it is not merely a seed, but a fruit. Provided with such an excellent device it is no wonder that the composites are so widely dispersed and so abundant. Witness the rapid covering of a burnt-over area with the fire-weed (horseweed).

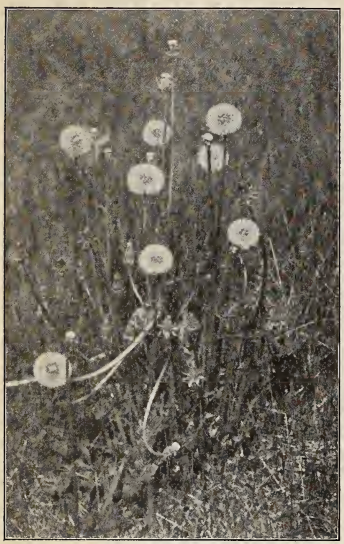


Fig. 144. Dandelion Gone to Seed.

Some of the grasses and sedges also have similar silken sails. So have the cat-tails. The Pennsylvania anemone has its fruit covered all over with soft down to enable it to float on the air. The fruit of the hairy anemone (pasque flower) and the wild clematis (virgin's-bower) has long hairy tails for the same purpose.

But in many instances the seed, and not the whole fruit, is provided with wings for dispersal. The milkweed seed illustrates this well. Each has a tuft of silk. So, too, our useful cotton is covered with soft fibres intended for aiding

in dispersal. We have made use of them in another way. Cottonwoods, poplars, and willows have fruit with similar cotton-covered seeds. In summer we can often see the air full of the floating seeds of the cottonwood, and they cover the earth like snow under the trees. Where a fire has destroyed the pines or other forests, these trees with cottony seeds, poplars especially, quickly reclaim the region.

The fruit and seeds of the catalpa are interesting. The fruit is a long pod, inside which are many flat seeds with each end fringed with a sail or wing.

Pines and other conifers have a similar plan. Their seeds lie on the inner face of the scales of the cones. When the cone is ripe the scales spread apart and the seeds loosen from the scale, taking with them a thin membranous wing for flying.

Water is another agent of seed distribution. Rains and running streams carry the seeds of many plants. The seeds of the knotweed (*Polygonum*) are provided with bladdery wings that enable them to float. Sometimes we see the pink knotweed occupying the whole length of a roadside ditch. That is because a few plants originally scattered their seeds upon the water which carried them along. Many other gutter weeds are distributed in like manner.

The seeds of willows and cottonwoods swim well and lodge along the banks of rivers and the shores of lakes. That is one reason why we find these trees in such locations.

The aquatic plants, of course, depend chiefly upon water currents for the scattering of their seeds.

Animals, though generally unwittingly, are great agents for the dispersal of seeds. All burs are intended to be carried away by animals. These burs are the fruits of plants and

are covered with spines, recurved hooks, etc. to catch into the fur of animals and the garments of people. Plants with burs are found abundantly where animals go, in the pastures, along the fences and roadsides, around barns. There we find cocklebur, burdock, sandbur, pitchforks, beggar's-lice, tick-trefoil, etc. Even the barbs or beards of grasses and grains act like burs. This is well seen in barley and in the squirrel-tail grass. In the latter each grain is provided with several long, slender, barbed awns. When the head is ripe it breaks up into the separate grains. Passing animals catch the barbed awns and the seed is scattered. The wind, however, may blow these light grains, the barbs acting as sails. Along almost every country lane and the roadways leading from the cities into the country we may see these bur weeds migrating. The cattle, sheep, horses, dogs, and men passing along assist them on the way. Burs have learned the trick of stealing rides.

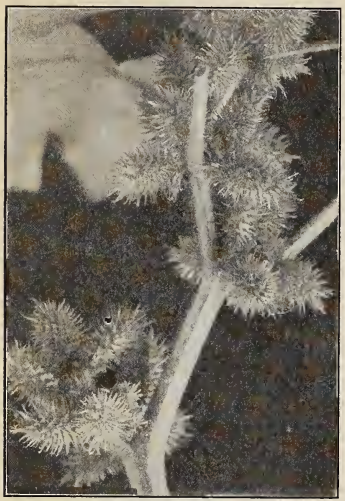


Fig. 145. Cocklebur.

Man has carried the seeds of cultivated plants from one end of the globe to the other. Wherever he goes he takes

with him such food and other useful plants as can be raised in the new region to which he moves. Thus wheat and other grains have been brought westward from the cradle of civilization in Central Asia, and our Indian corn, potato, and tobacco have been carried to the eastern hemisphere.

But with the intentional introduction of useful plants the

Fig. 146. The Bright Scarlet Fruit of the Waahoo Remains on the Bushes Long after the Leaves have Fallen and thus Attracts the Birds.

seeds of harmful weeds have also been brought in. Thus the Russian "thistle" was brought over from Russia with some seed wheat. Many other weeds such as daisy, dandelion, hemp, plantain, and corn-cockle were brought from Europe, generally unintentionally.

Water-fowl no doubt aid in the distribution of many marsh and water-plants. The wild rice, for example, is carried on the feet, bills, plumage, in the crops of ducks, geese, and other water-fowl, and is scattered on their wanderings.

The rosy-cheeked apple, the purple grape, and the luscious cherry all are excellent eating—all but the seeds or pits. These we throw away. Perhaps they will spring up somewhere.

The attractive colors, the fragrance, the delicious flavor, the edible pulp are all intended to attract animals to eat the fruit. The seeds are either not eaten or pass through the digestive tract uninjured. Birds, especially, help to disseminate seeds in this way. Along fences where birds are apt to rest, we find grapevines, gooseberry, raspberry, blackberry, elder, sumach, hawthorn, red cedars, and other vines, trees, and shrubs that bear fruit. Squirrels and other animals also scatter fruit seeds and nuts. Many squirrels have a way of burying acorns and walnuts either singly or in large piles. Some of these are pretty sure to germinate.

FIG. 147. Explosive Pods. (Sweet Pea and Balsam.)

The burning-bush or waahoo is an interesting illustration of a plant dependent upon birds for scattering its seed. In the fall the bright red fruit remains on the bushes long after the leaves have fallen off. This makes the fruit all the more conspicuous.

There are a few plants that do not rely upon the accidental agency of wind, water, or animals to scatter their seeds. They have devices of their own for forcibly throwing the

seeds to a distance. The sweet pea when ripe splits open and quickly curls the two halves of the pod into spirals, thereby snapping off the seeds. The pansy does a similar thing. Other plants also have such methods for snapping out the seed.

The common garden balsam and its wild cousin the touch-me-not have seed pods that when ripe and slightly touched split up into spiral parts, thereby throwing the seeds some distance.

Who will say that plants are uninteresting and stupid things?

Grasses and Cereals

Teach the pupils that grasses and grains are flowering plants. Let them bring early in summer, timothy, wild rye, June grass, and any grains that happen to be in flower. With a magnifying glass and with diagrams, study briefly the structure of a grass flower. Note that the more showy parts of flowers in other plants are here replaced by inconspicuous green bracts. Generally the anther filaments are slender and long, so that the anthers hang out of the flower and shake in the wind. Similarly the stigmas of grass flowers are long and feathery, so as to catch the pollen which is brought to them by the wind. The flowers of grasses are small and are generally clustered together in heads or spikes. Note the general appearance and growth of various grasses. Note the hollow stems, the solid joints, and the slender clasping leaves. Many grasses have large root-stalks.

Though it may be impossible to name all, it is instructive to collect as many different kinds of grasses as can be found

in a neighborhood. It will show the great variety there is. In the meadows and pastures are June grass, timothy, red top, bent grass, blue joint, and on the western prairies the buffalo grass, all valuable fodder. Millet is often sown in the fields for fodder. In our northern swamps and lake and river borders is wild rice. Some grasses are considered more as weeds: Squirrel-tail, old-witch's grass, wild rye, and sand bur are roadside weeds. Pigeon grass, green foxtail, and quack grass are common in the fields and elsewhere. Barnyard grass is tall and coarse, growing around barnyards and rich, low places. The lawns are made unsightly in midsummer by the low, spreading crab grass.

FIG. 148. Timothy Grass in Flower. (Notice the long pendulous stamens.)

The cereals should be studied from the botanical as well as from the commercial standpoint. Compare them with the grasses and it will be seen that they have the narrow, clasping leaves, the hollow stems, the solid joints and, also, the flowers of grasses. In fact they are grasses, cultivated for their seeds. Even our Indian-corn or maize, sorghum, sugar cane, and the bamboo are grasses.

A good time to study grains is in the fall. It may be

possible to find some belated plants still in flower. If so, the study of the flower will prove very interesting. Note the scaly floral envelopes, the feathery stigmas, and the pendulous anthers. Like the grasses the grains are wind pollinated.

Fig. 149. Grass Flower.

Fig. 150. Indian Corn.

Make a brief comparative study of the botanical features of the different common grains, including rice. Their commercial aspects can be taken up in the geographical work, but here is a good chance for correlation. Refer to the origin of grains and their cultivation in ancient times, in Babylonia and Egypt. In all civilized nations the cereals are the staff of life.

Study the wild rice of our northern lakes and swamps. This interesting plant produces grain that was used by the Indians. Aquatic birds, like the wild ducks and geese, and the various marsh birds feed much upon this wild grain. The seeds of many other grasses are eaten by many birds.

Indian corn is worthy of special study, on account of its

curious inflorescence. The tassel at the top is a cluster of staminate flowers. Note the great quantity of pollen that shakes out when they are ripe. This is carried by the wind to the silk, which forms the stigmas of the pistillate flowers. The ear is really a stalk (cob) on which are ranged in rows the pistillate flowers, which, however, are reduced to almost nothing but the pistils with the very long stigmatic styles, the silk. This cluster of pistillate flowers is enclosed in a protecting sheath of leaves (the husks).

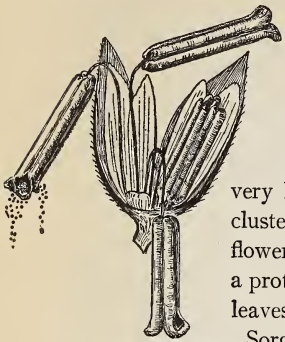


FIG. 151. Staminate Flowers from Tassel.

Sorghum, sugar cane, and bamboo may be studied in comparison with the other grasses.

FIG. 152. Ear of Corn, Pistillate Flowers.

Useful Plants and Their Products

A series of interesting and profitable lessons may be given upon the plants that furnish us with food, clothing, and shelter. These are especially appropriate in the lower grades, and can be nicely connected with the geography work. Take up such plants as the grains, including rice and Indian-corn, sorghum and sugar-cane; tea, coffee, and cocoa; fruit and vegetables; the fibre-producing cotton; flax and hemp, and the useful woods. Illustrate with as much of

the plant as possible, pictures, the products in different stages of preparation, etc. It would be interesting for the children to correspond with others living in the countries where these plants are raised, in order to make exchanges of plants and other nature or geographical material. Hemp and flax are easily obtained, and some of the children would no doubt be interested in trying to treat these plants for the preparation of the fibres. The cotton plant can be easily raised in the North. It may be grown in a window box in the school. I have several seasons started cotton in March, transplanted to the garden, and grown the plant almost to the maturity of the pods. If taken in before the early frosts such plants can no doubt be ripened in the house.

It is often surprising what ignorance is shown concerning the common woods used for furniture, buildings, and fuel. It would be well to have the children learn to recognize the most common kinds. A good time for this study is in the winter, when the boys are sawing wood for the family use. Let them cut thin sections of the different kinds of wood. Perhaps specimens may be obtained at a furniture factory, or other place where much wood is used. Some of this should be polished to show the grain. Collect pine of different kinds, fir, cedar, red and white oak, hard maple, white-elm, ash, birch, hickory, basswood, poplar, walnut, mahogany, rosewood, ebony, etc. Label these properly and place in the school cabinet. Note the hardness, color, grain, elasticity, strength, and other properties of the wood, and refer to the uses to which it is put, and the special properties that make it useful for these purposes. Such lessons would be especially desirable in connection with manual training.

CHAPTER XVIII

TREES

Trees are the giants of the plant world. They constitute a large element in the beauty and grandeur of the landscape, and they have always had a great influence upon man's existence and his development.

The tree should be studied as a flowering plant. As such it has the usual organs and functions.

Trees send their roots into the soil for anchorage and for the soluble minerals and water. Some have large tap roots that strike deep into the ground, the oak and butternut, for example. Others, like the spruce and birch, let the roots run out laterally not far beneath the surface. Hence they are easily uprooted in storms, while the oak proverbially withstands the blasts. The root extent of trees is surprisingly great, being about as large as the part of the tree above ground.

The wood of a tree is made up of concentric layers, which on cross section appear as rings, called annual rings. The age of a tree may approximately be told thereby. For the origin of annual rings see page 307. The older heart wood and the young sap wood generally show a difference of color, the former usually being darker. The sap wood is still active in carrying water, and storing sap, but the heart wood, though containing moisture, does not enter any more into

the life of the tree. The heart wood may decay out and the tree will still flourish, though, of course, weakened mechanically.

The bark is separated from the wood by a thin zone called the cambium or growing layer. This makes new wood on the inside, and new bark on the outside. In spring it is especially

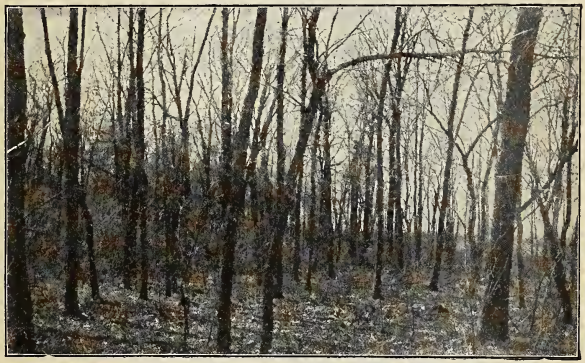


Fig. 153. The Forest.

active and large and can be easily broken, as is seen when the bark is slipped from a willow twig in making a whistle.

The bark also forms annual rings, but because of the wearing off on the outside, it is usually not very thick. In some trees it wears away fast and the bark remains thin. In others, notably the cork oak, it becomes thick. On account of the growth of the woody part of the stem, the old bark becomes too small and is fissured in a manner characteristic of each tree. The bark on the young trees, and on the branches and twigs of old trees, generally has a different color from that of the old, and is of course not so

thick. It is also smoother. When the trees feel the touch of spring, these thin-barked branches show a flush of color, red, brown, yellow, etc., that produces a pleasing effect in the yet leafless forests.

The branching of trees also is characteristic, nearly every species possessing its peculiar type or mode of branching. The spruces hold their branches horizontally and, the upper branches being younger and shorter, the whole tree has a tapering, conical appearance. The soft maple has a short stem which soon divides into several long main branches that make a rather small angle with each other, giving the whole tree a fan-like effect. The hard maple with its numerous branches has a very different aspect. The elms have a very characteristic form due to the way in which the branches grow. The typical form is with several main spreading branches which droop somewhat at the ends, although there is another common form with more rounded crown and irregular branching.

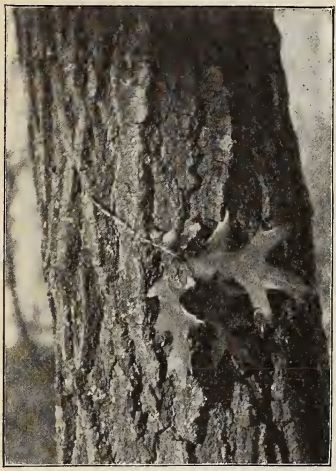


Fig. 154. Red Oak.

One ought to be able to distinguish the trees by the bark and mode of branching alone.

Winter buds are best studied on trees. The subject of buds, their protection and their development, was discussed on page 311.

It should be remembered that the foliage of trees has the usual function of leaves, namely, to carry on transpiration and to make starch. (See page 313.) Place branches of different kinds of trees, such as cherry, maple, elm, and others, in vessels containing equal quantities of water. The twigs should have very nearly the same leaf area. It will be noticed that different quantities of water are absorbed, and also that some of the twigs will be wilted sooner than others. This illustrates in a very rough way the rate of transpiration for the different species. The quantity of water given off from a tree is enormous. Mr. Ward in his study of the oak estimates that an oak may have 700,000 leaves, and give off during the summer no less than twelve tons of water from its foliage. This makes apparent the need of a large root system and also of plenty of rainfall.

The leaf arrangement is interesting. There is a prevailing symmetry and orderliness in the position of leaves. Study their arrangement on an elm twig and a maple, and compare.

The leaf mosaic, or arrangement, so as to cover all open space and yet not shade other leaves, should be studied in different trees. The effect of one-sided illumination should be noted in trees growing at the edge of a forest, or where shaded elsewhere.

For purposes of identification and for its beauty, study the venation, and also the leaf form in different species. A study of the terms: netted-veined, serrate, crenate, palmate, etc., for definition merely, is not nature-study. If these things

are studied it should be with some application in view, as the use of these forms in identification of trees and other plants.

The important function of the leaves of a tree being realized, it will be seen why a tree should suffer from the destruction of its foliage by cankerworms, as often happens.

In the autumn, as the soil is cooled and the roots are chilled, the flow of the sap is diminished, and the leaves are thereby affected. The life processes are accordingly checked. Most of the still useful substances in the cells of the leaf are absorbed and stored in the neighboring twigs and buds. The leaf cells are thus slowly dying, and undergo chemical changes that destroy the chlorophyll and reveal the reds, yellows, and other colors that were there before, or are now produced by the processes of decay. Thus the leaf puts on the gorgeous colors of autumn. Though there is a great variety of hues in the forest as a wnole, yet the individual species as a rule have certain colors peculiar to them. Sometimes there is a gradation of colors through a certain gamut. Elms, soft maples, and poplars put on clear yellow. Hard maples have yellow, orange, and red. The red oak turns a chocolate brown. Conifers, on the other hand, retain their green, though with subdued intensity, in the winter.

It is commonly said that frost causes the bright autumn colors. This is not strictly true. The chilling of the roots, even without a frost, begins the work of the fairy painters. The most brilliant colors of the forest are produced in cool, moist weather, with no frost. A severe frost will turn the leaves sere and brown, instead of orange, red, and yellow.

In cold latitudes the trees shed their leaves before winter. The leaves would freeze anyway and, if not, the too great transpiration when the roots were furnishing so little sap

would cause the death of the tree. So it is a good, though to us rather pathetic, thing that the leaves fall. Leaf fall is preceded by the formation of a corky, waterproof layer of cells at the base of the leaf-stalk. In due time the leaf falls off. It is not simply torn off by the wind. The corky layer referred to serves to sever the leaf from the tree. Some trees, like the maples and boxelder, shed their leaves early; others, like the white oak, retain them sometimes even till spring. Conifers as a class do not shed their leaves all at once. They do, however, lose their needles, which are falling more or less all the time as they mature, or are shaded too much by the younger growth. But since they retain most of their leaves green through the winter we call them evergreens. The tamarack, a conifer, however, sheds its leaves in the fall. In the warmer regions of the earth trees other than conifers retain their leaves in winter, and only shed them gradually like the conifers. The live oak of the southern states is an evergreen, but its northern relatives must shed their foliage in the fall.

Trees are flowering plants. This is very evident to all in the case of the apple, plum, hawthorn, locust, and other showily flowered trees. Yet the elm, oak, willow, and basswood, the cedar, and the pine, all have flowers. Though minute and inconspicuous, they are still very interesting when closely studied, and often very beautiful. Some tree-flowers were described on page 331.

There is a great diversity in the ways in which trees disseminate their fruits or seeds. Some fruit is edible, and animals thus scatter the seed. Some of this fruit is pulpy and juicy, and others are hard nuts with edible kernels. Some fruit is dry and inedible, and is then generally pro-

vided with wing-like devices for dispersal, or else the seeds are thus provided. Elm and maple fruits have wings. The seeds of the catalpa have feathery wings, and the cottonwood seeds are covered with a mass of down. Seeds and fruits of trees also float upon the water and may be thus scattered. Through the agency of man, orchard and shade

Fig. 155. White Elm in Flower.

trees are planted, and on our originally treeless prairies there are now on nearly every farm planted groves.

Trees, like other plants, are dependent upon temperature, moisture, light, and soil. Temperature is one of the chief conditions determining the distribution of species. Conifers as a class prefer the colder northern regions or the higher altitudes on mountains. There are, however, southern and lowland species. The deciduous hardwood trees also abound chiefly in the colder temperate regions. Some, like the wil-

lows and birches, extend far northward. Mahogany, teak, and the palms flourish only in the tropics. Oranges and lemons thrive in California, but not in Minnesota. Each species has a certain range to which it is limited principally by the climate. On the borders of these ranges the trees do not thrive so well. In high altitudes, or far northern lati-

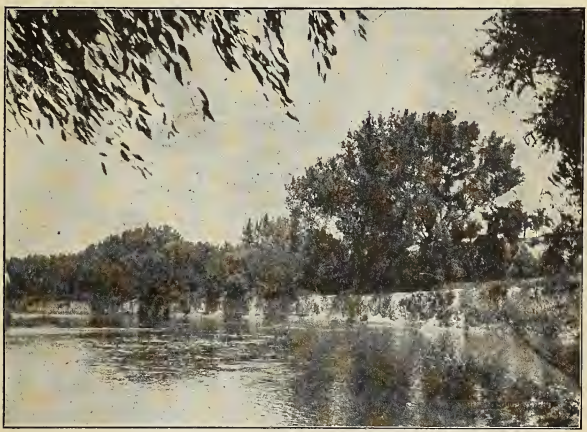


FIG. 156. Cottonwoods, Soft Maples, Boxelders, Elms, and Willows Like to Grow Along the Rivers. Their Seeds are Carried by Wind and Water.

tudes, the trees are stunted in their growth, and finally a limit is reached beyond which trees do not grow—the tree line.

Moisture is probably the next most potent condition determining the distribution of trees. Some trees, like the cypress of the southern swamps and our northern tamaracks, can grow only where they can stand with their feet in the water or water-soaked soil. In northern Minnesota one may

ride fifty miles or more through pure tamarack swamps. The soft maple and the willows prefer wet soil, and hence do best at the edges of streams, lakes, and sloughs. Elms also like a rather moist soil, and grow very large in the bottom-lands of rivers. But many trees can endure a dryer soil. The black oak and Jack pine will grow in very dry soil, but there is a limit even for these.

In a region where the annual rainfall is less than twenty inches trees grow only with difficulty, or not at all. The eastern half of the United States was originally forest covered. But as we go west we gradually see that the Big Woods are less luxurious and flourishing. The trees are smaller and stand farther apart. On this dividing line are straggling scrub oaks and poplars, and these also eventually disappear. In the valleys of streams and on the borders of lakes, there still manage to exist on the prairies various species of hard woods.

The principal reason for the treeless condition of the prairies is lack of rain. It is only under artificial culture that the young trees can become established. Once well rooted they manage to grow, though not as large as in better watered regions.

A visit to a forest will teach us much about the life of the individual trees, and the forest as a community of trees. In our northern or central wooded regions we find generally a mixed stand of hard woods, such as elms, oaks, maples, ironwood, hickory, butternut, poplar, etc. The trees are of all ages, from germinating seedlings to patriarchs centuries old. There are mature trees with leafy crowns 50 to 100 feet high, that have won in the struggle for light. There are younger trees in the shade of the older. Young

growth as a rule can endure more shade. There are also some low species, as the blue beach, the dogwoods, and others, that are shade loving. These shade-loving shrubs and the young growth constitute the underbrush, which in more open forests may be a veritable jungle.

Fig. 157, A Shelf Pore-Fungus.
(The chief part of the fungus is inside the tree, causing death and decay.)

In time the tree reaches a period of old age, when its vitality begins to diminish, and it is subject to the attacks of fungi and bacteria of decay or disease. The effects of insects, such as canker-worms that eat the foliage, and the bark and wood boring larvæ, are also more serious then. The heart-wood decays, perhaps, the branches die from the attacks of fungi and insects, and fall. Gradually the tree dies. Decay is hastened. The trunk and roots are weakened, and a storm uproots or breaks down the tree. We see many broken limbs, fallen tree trunks, and old stumps littering the forest floor. There they gradually rot and return to the soil the mineral matter and to the air the gases that were used in their upbuilding. In this process of decay many fungi and bacteria take an active part. We see shelf fungi,

toadstools, fungous incrustations, and lichens growing upon the dead logs and stumps, and even on the sick, yet living, trees. The noticeable fungous growth which we see on the outside is merely the fruiting portion, which is a part of a larger mass of fungous fibres and filaments that spread under the bark and within the wood of the tree. This invisible part of the fungus is what does the chief work of decay. Sometimes by removing the loose bark of a decaying log the white vegetative part of the fungus may be seen. Fungi perform a useful work in removing the dead timber that otherwise would so litter the ground that no more growth could come up. Besides the fungous decay there is also chemical oxidation of the wood which hastens the disintegration.

The ground beneath the trees is covered with a thick deposit of matted and felted leaves. Dig up this leaf mass. Notice on the surface the recently fallen leaves, then, below, the leaves of former years more aged and decaying. Still farther down the leaves are crumbling, and soon the leaf form can no more be made out. The lowest part is composed of a light porous mass of black material, which is the result of the decay of the leaves. This black substance is called leaf mould, and consists largely of carbon, which gives it its black color. This mould is very fertile, and is used by gardeners for potting and bedding plants. A forest thus fertilizes itself by the fall and decay of its leaves.

The trees in a forest influence each other's growth. A tree grown in the open, with plenty of light from all sides and elbow room, is not as tall and slender as it would have been had it grown among other trees. In the forest the trees contend with each other for the light, and try to over-

top each other. The one that succeeds will get most light, and therefore grow the best. In the forest the lower branches of the trees are killed by the shade of other trees, and in time they fall off. The wound left by the branch, the knot hole, generally heals over with a new layer of wood and bark. In the forest the lower branches may not be within thirty

FIG. 158. An Open Grove of Hard Maples.
(The trees have rounded crowns, low branches.)

or forty feet of the ground, while in the open the same tree would have had a short thick trunk with branches growing low, and rounded crown.

For the first ten years, the rate of growth of trees is slow. It is most rapid for several decades after this, and slower again later. How long do trees live? That depends upon the species. Some, like the poplars, are short lived, a hundred to a hundred and fifty years. Maples and oaks live

several centuries. The cypress lives five hundred years. The giant sequoias of the West probably saw the light before the Christian era.

Forest Influences and Uses

Forests exert some important physiographic influences. It is still a moot point how far the presence of forests affects the rainfall of a region. It is probably more correct to say that there are trees because it rains, than that it rains in places where there are forests. The cooling effect of the transpiration of a forest may hasten the precipitation of passing clouds. But on the whole the rainfall has not been noticeably affected in this country by the clearing away of the forests, or the planting of trees on the prairies. The cases of Persia, Spain, and other countries usually mentioned to show that the absence of extensive forests causes aridity of climate are now considered rather doubtful illustrations, as it is not well proved that those lands ever had extensively wooded areas, in historic times.

Forests temper the force of the winds, and are very useful as windbreaks for the hot winds of summer and the cold winds in winter.

Forests protect the soil from erosion. In level regions this is not so evident as in hilly or mountainous countries. The hills should be capped with forest growth, not only to keep the soil on the hills and to prevent their being gullied with water courses, but also to protect the fertile valley lands from the gravel and sand that would otherwise be carried down upon them.

Forests conserve the rainfall. The spongy, porous mass of leaf mould on the floor of the forest very materially acts as

a check on the flow of the water, and it tends to hold it absorbed a long time. In this way, especially in hilly and mountainous countries, the forests check the rapid off-flow of the water, thus preventing disastrous floods in the rivers, and also making the streams of more constant volume. The water seaps out slowly under the leaf mould, or is absorbed by the earth and given up slowly in springs, long after the

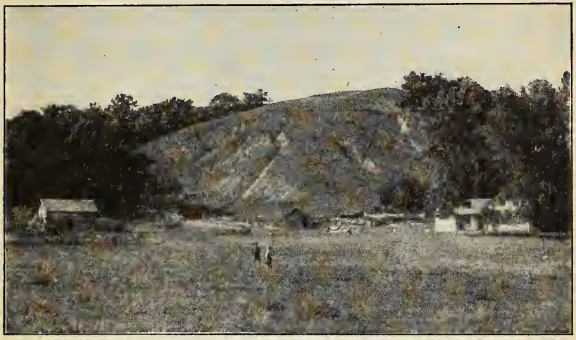


Fig. 159. A Denuded Hill Showing Effects of Erosion.

rains have ceased. Hence the intermittent rainfall will appear as a steady supply of the rivers, which therefore have a more even stage of water, a very important point in the navigation of many of our streams and in irrigation. This effect of forests is perhaps the most important. In recognition of this, the government has set aside great forest areas in the headwater regions of many western streams. Try this experiment: Place one end of a broad board or trough in a sink, or pail, and raise the other end. Pour water on the upper end from a sprinkler. Note how quickly it runs off the board. Now

place a mass of cotton batting on the board and repeat the experiment. Note how much more slowly the water runs off, but how much longer it continues to trickle out. By placing some leaf mould on the inclined board the experiment may be repeated and the retarding effect of the same noted.

One other fact should be mentioned in this connection. Forests on the hills are a perennial supply of fertility for the lowlands. The waters that seap through the leaf mould take up soluble matter and convey it to the fields below.

In primitive times man was very dependent upon forests for fuel, shelter, fruits, nuts, roots, and game. And man to-day makes much more use of forests than did his primitive forefathers. Forests are used to-day as windbreaks and shelter for man and beast, as game preserves, as pleasure parks, and as summer and health resorts. The wood is used for fuel for our homes, factories, and kilns. The fuel value of our forests is enormous. Even coal, derived from plants, may be considered under this head.

The railroads require millions of ties and telegraph poles. Vast amounts of timber are used for telephone poles and for fence posts. Large timbers are used for bridge and foundation pilings and for supporting pillars in mines. Small, slender saplings are used by the million for hoops, bean and hop poles.

A number of industries are dependent upon forests. The charcoal industry, once very important, is one. Oak and hemlock bark are used for tanning leather. In southern states the pitch and turpentine industry flourishes in the pitch pine regions. In the northern states the maple sugar industry is carried on in forests of hard maple. Different kinds of nut trees afford profitable industries in various parts

of the land. Every year great numbers of balsams, spruce, and other evergreens are cut and sold for Christmas trees. Forests are used for pasturing cattle, sheep, and goats.

A great deal of cheap paper, used especially in newspapers, is now made from wood pulp. Soft woods, such as poplar and spruce, are cut into small pieces, and macerated or ground into a pulp which is pressed and rolled into paper. Considering the uselessly large size of our metropolitan papers, we can readily see that in order to supply the demand for paper large areas of forest land are being denuded.

The greatest use we make of forests is for lumber for buildings, bridges, fences, boxes, sidewalks, furniture, and many other purposes. This demand is rapidly destroying our forests. We use over 30,000,000,000 feet of lumber per year in this country, of which 75 per cent. is pine and other conifers. This is three times as much lumber per capita as is used by Europeans. Our "frame" houses illustrate the great use we make of lumber. When our forests are gone, more costly yet more enduring brick and stone will be used. But this may force into rented tenements or apartment houses a large part of our population, who otherwise would have built separate wooden dwelling-houses. The destruction of our forests may thus be seen to have an important social effect.

White pine is the king of the lumber trees. It is common in Minnesota and other northern states and in Canada. Maine is called the Pine Tree State, but it is no longer so in fact, for the great white pine forests there have been practically destroyed. Later, Michigan held chief place in white pine production, then Wisconsin, and now it is Minnesota, though even here the end of the industry is in sight.

White pine is so valuable because it is light, soft, and easy to cut and nail, durable, and insect proof.

In the South the Georgia longleaf, and the North Carolina hard pines are the chief woods used for lumber. These are often used in the North for interior finishing, ceiling, and flooring. They are yellow pines.

The cypress of the southern swamps is also extensively used now for lumber. In the North the spruce is a common building stuff, and hemlock, though poor in quality, is also used. In the western coast forests the redwood is the chief lumber tree. It is brownish, soft, and very durable, and is largely used for shingles.

The hard woods are more difficult to saw, plane, and nail, but they are stronger, and tougher than the pines, etc., and therefore find many applications. They also show a fine grain, and take polish well, hence they are much used for interior finishing and for furniture. Heavy oak timbers enter into the construction of buildings and bridges.

These are some of the chief uses of lumber. The industry in its various stages is an interesting one to study. Children like to learn about lumber camps, the felling of the trees, the dragging of the logs to the rivers, the driving down the streams, the log booms, the saw-mills, lumber yards, the shipment of the lumber, and the various uses to which it is put. It would be instructive to trace a white-pine tree from the forest to the various purposes for which it is used.

Arbor Day — Beautifying School-grounds

Arbor Day is now universally and fittingly observed by the schools. Secretary Wilson in his report in the 1899 "Year Book of the Department of Agriculture" says: "Prom-

inent among the agencies for interesting the children in forest matters is the observance of Arbor Day. Instituted in Nebraska in 1872 by Hon. J. Sterling Morton, Secretary of Agriculture, 1893–1897, Arbor Day has made its way from state to state until, at the beginning of 1900, provision for its observance has been made in every state and territory. Its central idea is the planting of trees by school children on dates fixed by the governors of the various states or by other authorities. The planting is usually accompanied by exercises, sometimes elaborate, intended to impress upon the children the beauty and usefulness of trees, and to encourage the care and preservation alike of shade trees and forests. While the planting accomplished may have very little economic value, the institution of Arbor Day may fairly be said to exercise immense influence in exciting affection and respect for trees in the coming generations, and so to prepare a body of sentiment which will assist powerfully hereafter to bring about the general practice of conservative forestry." The broader purpose and the great practical importance of Arbor Day is thus seen from these words of Secretary Wilson.

But Arbor Day has another and more direct value. Through its observance the grounds of many schools can be improved and beautified. In a circular addressed to the county superintendents, the State Superintendent of the schools of Illinois, in 1903, makes the statement that there were in that year still over two thousand schools without a single shade tree. Probably a much greater number were sadly in need of improvement as far as the grounds were concerned. The conditions of the country, and even village and city, schools are similar throughout the United States. Not enough has been done to make the school-houses

and grounds attractive or even respectable. There are many "ragged beggars" still sunning at the country cross-roads. Many jails have finer grounds, and consist of more substantial, and elegant buildings than our country and village schools. Most farmers surround their homes with groves and flowers, but the country school across the road where their children go is barren and ugly. No wonder

Fig. 160. A Typical Country School—in Need of Shade Trees.

that so many children dislike to go to school. Make the school-houses attractive inside and out, surround them with shade trees, shrubbery, flowers, and grassy lawns, and the pupils will be drawn to such schools rather than repelled by their barrenness and ugliness.

Since the regular observance of Arbor Day much has been done to make the surroundings of the rural and town schools more attractive. Much, however, has been done poorly and without system. The way to improve a school-

ground is to begin at the beginning. The ground should first be properly graded and levelled, so that it is even and the drainage right. Stumps and stones should be removed. Perhaps it is necessary to bring good, black earth to put on poor soil, if it is desired to grow grass. There should be a grass plot, at least, directly in front of the schoolhouse. The children should be required to respect this

FIG. 161. A Beautiful Farm Homestead Just Opposite the School.

area and permit the grass to grow. On the playground proper the grass will probably not grow. This should be well drained and covered with sand or gravel, so that even in wet weather it will be possible to play upon it without tracking much dirt into the school.

The preparing of the grounds and the planting of trees should not be simply a matter for the teacher and pupils, but to ensure success the school officers and the patrons of the district should help. There should be a system agreed

upon by the patrons at a district meeting. Competent men should be employed to prepare the ground and to select and plant the trees, for the teacher and pupils are generally not good tree planters. The teacher should take an active interest in all this. She may be of great influence in the community, and by tactful suggestions she may get the people of the district to assist her in the work of improvement. If all cannot be aroused, perhaps a few may be. These could bring their teams, with ploughs and scrapers, some Friday afternoon or Saturday, and with the help of the children could prepare the grounds fairly well.

The tree planting should not be done in a haphazard or promiscuous way, but should be well thought out. The kinds of trees to be planted should be well chosen, not with a view to rapid growth alone, but to the beauty and suitability of the tree in after years. Too many school-grounds have short-lived, undesirable soft maples, boxelders, and cottonwoods planted upon them simply because they grow fast. In general, trees should not be planted upon the playground proper, where they would interfere with the games of the children, but should be placed along the boundaries of the school-grounds and around the unsightly outbuildings. On the prairie, where the winds of winter and spring are strong and penetrating, there should be thick belts of trees on the windward sides. These will act as windbreaks. Here the trees should be planted in several rows. In planting trees on the edges of the grounds, spaces or gaps should be left for viewing the landscape beyond, especially on the lee sides. The trees may be planted in straight rows, or arranged irregularly in clumps, to give a more natural effect. The latter is best on large grounds. The front of the grounds

should not be planted with continuous belts of trees so as to obstruct the view of the school-house.

Shrubbery is very effective on school-grounds. It may be grown on the borders of the belts of trees, and in the corners and around the outhouses. Hedges also of low shrubs may be grown along the front of the grounds.

In selecting trees be careful to take those adapted for the soil and moisture conditions that prevail on the grounds. Among the trees best adapted to various soils, and beautiful and long-lived, are the elms, maples, and oaks. Walnut, butternut, chestnut, beech, birch, mountain ash, pines, balsams, cedars, and spruces should also be planted for variety and beauty. If the grounds are extensive other trees may be planted for study and experimental purposes. The trees on the schoolgrounds furnish many topics for nature lessons. On a large school-ground fruit trees of various kinds could be grown. It is a good plan to plant some of the trees by groups, that is, have clumps of elms, maples, pines, etc. This makes a more beautiful and striking effect. Evergreens especially should be planted in groups. These look well in the corners at the back of the grounds and around the outhouses, and they also afford shelter and nesting places for birds. In beginning a school-ground plantation there is no objection to the planting of fast-growing trees like box-elder, poplars, cottonwood, and catalpa, providing these are not the only kinds. If other more lasting and beautiful trees are planted at the same time, the more rapidly growing kinds will afford pleasant shade while the slower growing kinds are small. But as these grow tall the less desirable kinds should be cut out.

There are many ornamental shrubs that may be planted.

The elder, gooseberry, dogwood, waahoo, hawthorns, holly, and roses are pretty wild shrubs. Among desirable cultivated shrubs are lilacs, snowball, flowering currant, bush honeysuckle, barberry, spirea, hydrangea, etc.

Vines also may be very effectively used in hiding unsightly buildings, old stumps, fences, etc. Our common woodbine or Virginia creeper is one of the most easily grown and hardy. The variety that forms adhesive disks at the ends of the tendrils with which it holds to the walls, etc., is the best, as it does not need artificial support. The bittersweet grape-vine and climbing honeysuckle are other excellent vines. The berry-bearing shrubs and vines attract the birds.

It is best to get trees for planting from a nursery. If the whole plan is to be carried out in one year the planting must be done by experienced men hired by the school-board for the purpose. If only a single tree or a few trees are to be planted, it would still be better for one who understands to do the work. But in case it is impossible to get such practised assistance, the teacher and pupils, by observing strictly the following rules, may succeed in successfully raising a tree. Too often the Arbor Day planting is simply an illustration of how not to do it, and there are too many dead or dying trees thus planted that are simply an irony on the occasion. Great care should be taken to transplant a tree so that it will not suffer too much injury, but even under the best conditions transplanting is a severe shock to it. If trees are bought at a nursery they will probably be properly dug up and prepared for transplanting. They may be got from the forest as well. In general, younger trees are more successfully transplanted. For windbreaks, trees two or three

years old should be planted. For other purposes older trees, from one to two inches in diameter, are better. In digging up a tree, try to keep roots of from one to two feet in length. Mutilate the roots as little as possible, and leave many small rootlets. Cut off broken or injured roots, and cut off most of the branches, as otherwise too many leaves would be produced for the roots to supply with water. Elms may even have all the branches removed and present the appearance of bare poles.

Trees are best planted in the dormant condition in early spring, before the leaves are out. For this reason, Arbor Day is usually set in April or early May. It is not at all essential, however, that the school planting be done upon the day set by the governor.

The place where the tree is to be planted should be ready for the tree as soon as it is dug up. The hole should be large enough to give room for the roots to lie in their natural position without being cramped. Unless the soil is very damp the tree should be set from one to three inches deeper than it grew before transplanting. If the soil is very hard and clayey it should be broken up well below the tree for some distance, and also around it, so that the roots may penetrate more easily. By digging extra deep and throwing in broken tile, stones, etc., and then covering with good loamy soil, both proper drainage and good soil are provided for the young tree. In case the soil is very sandy and poor, a larger hole should be dug and filled in with good loam to give the tree a proper start.

The tree to be transplanted should be quickly transferred to the new location, after being dug up, for it is very important that the tender roots and rootlets should not become dry and thus be killed. If far to carry, cover well with moist straw,

excelsior, or burlap. Small trees may be carried in a pail or other vessel of water. Set the tree in the prepared hole. Throw in fine soil well among the roots. After the roots are covered several inches press the soil down well with a rammer or with the heel. If the soil is very dry, several pailfuls of water should now be poured on. Repeat the process of throwing in several inches of earth and stamping. The last two or three inches should not be put in hard, but left as loose as possible, to serve as a mulch to prevent the evaporation of the moisture about the roots. A surface application of well-rotted manure acts as a good mulch and also as a fertilizer.

Fig. 162. Wild Cherry Healing Wounds.

(Cuts wantonly made to remove staples holding a barbed wire fence.)

The trees must not be too much crowded, else they will become slender. They grow more stocky and with more rounded crowns if they have plenty of room and light. In general, trees should be planted not closer than twenty or thirty feet, unless close grouping is especially desired. As the trees get larger they may have to be thinned out, the finest and most regular being retained.

After a tree is planted it should not be neglected and allowed to die. In seasons of prolonged drought newly planted trees are very apt to die from lack of moisture. Daily watering, a pailful or so, is not of much use. When trees are watered they should be given about a barrelful at a time, every two or three weeks. Careful cultivation and

loosening of the ground between and around the trees will keep in the soil moisture, and do more good generally than watering. Perhaps a neighboring patron or his boys will agree to take care of the transplanted trees on the school-ground, during the critical period of the first summer.

Trees close to the playground, where they are apt to be injured in the play of the children, should have guards placed around them. The children should be taught to take a personal interest in the school-ground trees, and feel a desire to take care of them. In general, they may be safely trusted to respect the improvements made on the school-grounds.

I would suggest that some of the seedlings of oaks, walnuts, elms, maples, pines, and fruit trees started by the children in the window boxes be transplanted to the grounds. If these little trees can be safely raised to a self-supporting condition, it will speak well for the interest and care of the pupils in their development. If a record of these seedlings could be kept in the school, it would be very interesting in subsequent years to those who took part in the planting.

Arbor Day may be made the occasion also for pruning and trimming the trees already planted. Perhaps there are enough trees on the grounds. Perhaps there are too many. If the grounds and the house are too much shaded some of the trees should be removed. Too many trees about the school-house are often as bad as too few. In many cases school-houses are built in the woods. Then the work becomes one of clearing the grounds. This should be done with judgment. Not all the trees should be cut away, but those on the edges of the ground and elsewhere, if desirable, should be left. Preserve the best ones.

If nothing remains to be done in the way of tree planting,

Arbor Day may be utilized for a general cleaning up of the grounds. Rake up the rubbish, burn or remove it. Repair the fences, etc., make flower-beds, and transplant the flowers started in the window-boxes. (See page 258 on school gardening. Flower lists, page 295.)

An excellent thing to do on Arbor Day is to plant perennial

Fig. 163. A Street Beautified by Shade Trees.

plants, such as bleeding-heart, peony, larkspur, honeysuckle, columbine, iris, tulip, lily, golden-glow, hollyhock, etc. These will do well with very little attention, and come up year after year. The bulbs or roots may either be bought or contributed by the children from their home gardens. (See list of perennials and bulbs page 296.)

It is customary on Arbor Day to render a special programme relative to the planting and the uses of trees. This may either wholly or in part be given in the open. This

might be made an occasion for inviting the patrons and civic authorities, and good might be accomplished outside of the school in the way of civic improvement in beautifying streets, lawns, and parks. The following are suggestions for Arbor Day programmes: Purpose of Arbor Day. Origin of Arbor Day. Our forests. Uses of forests. Uses of different kinds of woods. Destruction of our forests. Forestry laws. What is forestry? Ornamental and shade trees. Windbreaks. The nursery. Descriptions of certain trees. Trees on city streets. Trees and school-grounds. The beauty of trees. Pleasures derived from trees. Trees and literature, with selections. Trees and history. How old some trees are. A development lesson on a certain tree. These topics may be presented by the pupils as essays or recitations. On the grounds perhaps there might be processions and tree planting songs. Let there be talks by practical tree planters, farmers, nursery men, and others interested in the raising and preservation of trees. Perhaps an illustrated lecture on trees or forestry may be arranged for in the evening, to which pupils and parents could come. In graded schools several rooms, or all, may unite in these exercises. An excursion to some picturesque wooded spot, or a park, would be very appropriate. Remember that Arbor Day can, and should, be made an opportunity for disseminating a knowledge of trees and forestry, and for cultivating, in the patrons as well as the school children, a desire for home and city improvement by planting trees and flowers.

Teachers should send for the following pamphlets on Arbor Day: "Arbor Day: Its History and Observance," by N. H. Eggleston, and "Tree Planting on Rural School Grounds," by

Wm. L. Hall, both of which may be secured free of charge from the United States Department of Agriculture at Washington. Bulletin 160, "Rural School Grounds," is also helpful, and may be secured from the Cornell Agricultural experiment Station, Ithaca, New York. These have important suggestions for tree and flower planting, and also for pro-

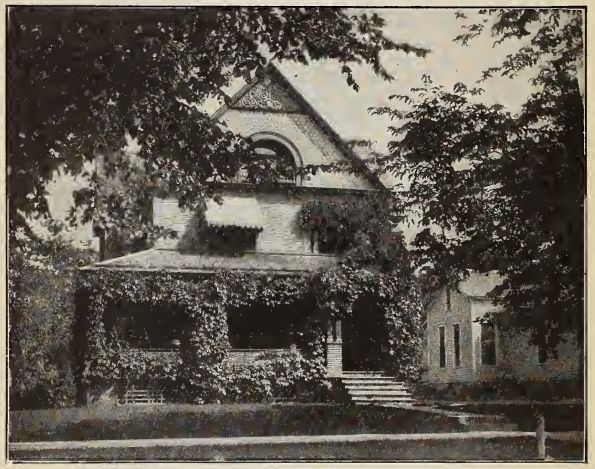


Fig. 164. Trees and Vines Improve a House.

grammes. Send also to your State Superintendent of Schools for circulars on Arbor Day. The state superintendents, of Wisconsin, New York, Illinois, and others have issued for years interesting and suggestive circulars for Arbor Day programmes.

In many schools the features of Bird Day are very appropriately combined with those of Arbor Day.

PLANTING A TREE

What does he plant who plants a tree?
He plants a friend of sun and sky;
He plants a flag of breezes free;
The shaft of beauty towering high;
He plants a home to heaven anigh
For song and mother croon of bird,
In hushed and happy twilight heard—
The treble of heaven's harmony—
These things plants he who plants a tree.

What does he plant who plants a tree?
He plants cool shade and tender rain,
And seed and bud of days to be,
And years that fade and flush again;
He plants the glory of the plain;
He plants the forest's heritage;
The harvest of the coming age;
The joy that unborn eye shall see—
These things he plants who plants a tree.

What does he plant who plants a tree?
He plants in sap, and leaves and wood,
In love of home and loyalty,
And far-cast thoughts of civil good—
His blessings on the neighborhood.
Who in the hollow of his hand
Holds all the growth of all our land—
A nation's growth from sea to sea
Stirs in his heart who plants a tree.

—Richard Watson Gilder.

CHAPTER XIX

FLOWERLESS PLANTS.

A BRIEF study should be made of the commoner and typical flowerless plants. Most plant species belong to this class, yet, on account of their generally small size and inconspicuous appearance, they are far less noticed by the average observer than the more showy flowering plants, such as "flowers," grasses, weeds, and trees.

It is impossible to teach children the detailed differences between flowering and flowerless plants. This essential difference, however, should be brought out, that the former generally have conspicuous flowers—seed-forming organs, while the latter reproduce more prominently by means of cells, called spores, which are not formed like seeds. The advanced botanical student, however, knows that there is a less conspicuous process of reproduction in the flowerless plants which is essentially the same as seed formation in higher plants.

Ferns are the largest common flowerless plants, and there is a great and beautiful variety of them, brakes, spleenworts, shield ferns, maidenhair, polypody, etc. It is a pleasant thing to collect and study ferns in their native haunts. Brakes and maidenhair ferns flourish abundantly on rich, wooded hill-slopes. With their great fronds the brakes add a tropical effect to our northern woods. The beautifully curled

"fiddleheads" of the young fronds are interesting. On rocky ledges and cliffs are found various spleenworts and cliff brakes, and in the marshy lowlands are shield ferns and others.

Ferns make fine herbarium mounts. As far as possible get the children interested in collecting, pressing, and naming the ferns of their locality. Have them notice well the habitat of each. Let them dig up fern rootstalks and plant them in a shady corner by the school-house or at home. The north side of buildings is a good place. The ground should be rich, containing much decayed wood. Chips, sawdust, leaves, or rotten logs and stumps should be buried in the soil where the ferns are to grow. Maidenhair, and other wood ferns, and the cliff brake do well in window-boxes.

FIG. 165. Spore Dots on the Under Side of a Fern Leaflet. (Photomicrograph.)

Examine the rootstalk and note the young shoots. Observe the way the frond is lobed and dissected. Examine the under side of a ripe frond, and note the little spots on the lobes. These are spore (not seed) cases. Shake out some of these spores on a sheet of white paper and note their minuteness and great number. Try to raise some fern from the spores. Sow the spores on some earth in a flower pot, and wash them in by sprinkling with water. Cover with a piece of glass and keep moist and warm.

A curious plant often found on sandy, or gravelly, wet banks along rivers and railroads is the Horsetail or Scouring Rush

(*Equisetum*). Early in the spring there arise from a creeping rootstalk flesh-colored stalks with cone-shaped structures on top. The stalk is jointed and at the joints are circles of scale-like leaves. The cone at the end bears the spores. These can be shaken out when ripe. There is another kind of stalk sent up later in the season when the spore-bearing stalk is dead. This is green, is also jointed, and in the common field horsetail is much branched at the joints. The stem and the branches bear small scale-like leaves which, however, are not adapted to form starch, as they are not green. The stem is green, and it makes the starch which is stored in the rootstalk and in the new buds or shoots of the spore-bearing stalks. One species of *Equisetum* has unbranched stems, which are jointed and grooved and have a very gritty feeling due to silica in the tissues. On account of this grittiness the plant was formerly used for sandpaper, and was called the scouring rush.

Fig. 166. A Moss-covered Boulder.

The mosses constitute another great class of flowerless plants. Gather with the children mosses of different kinds.

Note the great variety of form and also the great variety of habitats, that is, the places and conditions where they grow, on trees, on moist ground, on rocks, on cliffs. Note the general leafy structure, the hair-roots, and the varied spore-cases at the top of the stems. Examine these cases with a magnifying glass and note the interesting ways in which the cases open, by valves, chinks, and lids. Can you see the spores?

Fig. 167. Liverwort Encrusting a Dark, Moist Cliff.

Growing in wet places on ledges and cliffs, and on boards near springs or in damp ravines in shady places, are flat, lobed plants, the Liverworts. These are attached by numerous hair-roots. On the upper surface may be seen plainly the large breathing pores. The surface of the plant is marked off in diamond-shaped areas, the breathing pores being at their centres. At maturity one will find umbrella-like projections growing on the plant. These are the spore holders. There also may be little cup-like structures with egg-like masses in them. These also are reproductive devices, the little egg-like masses breaking off, washing away, and germinating into new plants.

Another interesting flowerless plant, of which there are many forms, is the Lichen. These are usually flattened plants growing upon trees, rocks, earth, and cliffs. Generally they are of a bluish-green color, but often they are yellow, red, and black. Many form an irregular crust; others are much branched and dissected. Some forms present a tufted or thread-like structure. Visit a pile of cordwood and note how many kinds of lichens may be found on the bark. Note that certain species are found only on certain kinds of trees. A visit to a forest or to a boulder field will show many other kinds of lichens. The faces of old weathered cliffs are often covered with them.

FIG. 168. Agaricus Campestris.
(Common mushroom—edible.)

There is a great class of flowerless plants called Fungi. A fungus has no chlorophyll, and therefore cannot make its own food (starch), and derives it from the living or dead tissues of other plants, or from animals.

The most conspicuous fungi are mushrooms, or toadstools, and puff-balls. It is well that pupils should learn a little of the general structure and habits of these peculiar plants. We speak of mushrooms growing in a single night, but in reality where mushrooms appear thus suddenly there

has been a long period of growth and preparation underground, or below the surface. The body of a fungus generally consists of a collection of fibrous threads or filaments growing in the decaying bark or wood of trees or in the soil. These are the vegetative part of the plant. They may often be seen by stripping the bark from rotten logs, or by carefully removing the soil around a growing toadstool. Then masses of white threads ramifying in all directions are seen. These are the vegetative or nourishing part of the plant, feeding on the decaying organic matter in which they grow.

FIG. 169. Development of Mushroom. Fungus Filaments, Buttons and Caps. Edible Agaric.

At maturity or under proper conditions there arise peculiar fruiting structures, the parts which we generally see exposed and call the fungus.

Collect some of the common field mushroom (*Agaricus campestris*) found in fields and pastures and along roadsides. This is umbrella-shaped. Under the conical cap are many radiating plates called gills. On these gills the spores develop in great numbers. Lay a ripe fungus (one whose gills are brown) gills downward on a piece of white paper, and protect with a bowl or bell glass from the air currents. Leave several hours. A beautiful "spore-print" will be formed. Note in the field mushroom that there is a ring of membranous appearance around the upper part of

the stem. Compare with younger plants. In these there is a membrane stretched across the gills from the cap to the stem which later tears away from the cap, and adheres as a ring to the stem. The spores and gills are at first white, then, as the mushroom becomes older, turn pink, then brown. In the field agaric there is no membranous cup at the base of the stalk. Note this by carefully digging up a plant so as to get all of the stem. This species and hundreds of other fungi are edible. Their nutritive value, however, is not very great.

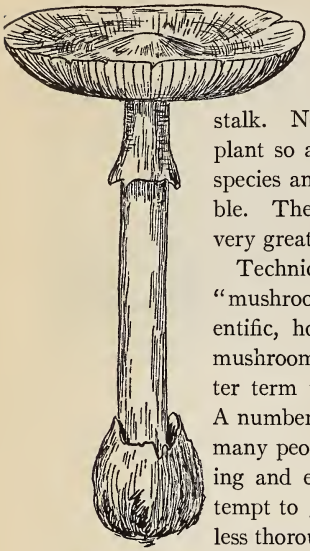


FIG. 170. Amanita. (Poisonous.)

Technically there is no distinction between "mushroom" and "toadstool." The unscientific, however, generally limit the term mushroom to the edible forms, and the latter term to the non-edible and poisonous. A number of fungi are very poisonous, and many people are killed by carelessly gathering and eating them. One should not attempt to gather mushrooms for eating, unless thoroughly acquainted with the common edible and dangerous kinds. There are only a few poisonous mushrooms. A common very poisonous form, the deadly amanita (*Amanita phalloides*) usually grows in the woods, though it may occur in pastures and fields with edible mushrooms. This fungus looks much like the edible field agaric, but may be distinguished from it by the fact that its spores are *white*, not brown, in maturity. Moreover, it has a cup-like envelope around the stem

at the base. Though there are exceptions to these rules, the beginner at collecting fungi for the table should not take immature fungi whose true character cannot be told.

Reject fungi with enveloping cups at the base of the stem. Reject brightly colored fungi. Do not take fungi with gills white at maturity. Do not take toadstools that have tubes or pores on the under side. Do not take fungi with a milky juice. Before eating the fungi the novice should show them to an expert collector.

Fig. 171. Wood-destroying Toadstool.

Puff-balls are globular fungi whose spores develop inside the mass and escape when the ball ruptures. Some attain a large size, a foot or more in diameter. One form has a thin rind which bursts at the top and, when pressed, emits a cloud of fine spores. Puff-balls are found in fields and pastures and are edible in the white stage.

Some fungi form shelf-like projections on trees and fallen logs, and on stumps. Some of these have gills (shelf agarics); others have myriads of small pores or tubes in which the spores form (*Polypores*). Others again have numerous fine teeth on the under side on which the spores form (as in *Hydnum* of the hedgehog fungi); in others the spores are borne upon branching surfaces, as in the coral-like *Clavaria*. Some fungi spread out on stumps and logs in gelatinous masses.

Fungi play an important part in the economy of nature. Many species grow in the wood of trees. They generally enter the tree as a spore by some wound, as a scar, or broken branch. From this point the vegetative fibres of the fungus ramify through the wood, killing the living tissues, weakening and rotting the wood, so that it is often ruined for timber. Such fungous decay generally results in the death of the tree. The fungus continues its work, until finally the tree is so much weakened that it is blown down in some storm. Still the work of the fungus goes on. The fallen tree decays, crumbles, and is added to the mould on the forest floor. In time the substance of the tree is practically entirely decomposed and returned to the air and the soil from which it originally was derived. In this work of decay fungi are really beneficent agents. Though it is pathetic to see a fine tree decay, yet every tree reaches a period of maturity and then declines, and should finally make room for new growth. If it were not for the work of the fungi and bacteria of decay, the dead trees would so choke the forest that no new growth could develop.

PART III

A COURSE OF NATURE-STUDY

CHAPTER XX

A GRADED COURSE OF NATURE-STUDY

It requires some temerity to select and arrange the material for a graded course in nature-study. The author recognizes his inability to plan a course that will meet the wishes of every teacher, and the impossibility of making any plan that will stand for all time, even if that were desirable. Any plan, however perfect to-day, might not fit to-morrow under a changed curriculum or under the new conditions imposed by the demands of a society having different views of education from those held to-day.

And yet the greatest evil in our present-day teaching of nature-study is that it is unrelated and unorganized. It is too scattering. A teacher in a certain grade will teach her nature-study without reference to what has been taught in previous grades or what is to come. As a result there is much repetition, and there can be no proper development of the study. There should be a continuity and a unity in the different branches of nature-study, not only for a particular grade but for the whole course. For example, in botany the work in the lower grades should serve as a foundation for that in higher grades. The subject should be naturally and logically developed throughout the course. A certain number of common flowers or trees should be learned the

first year, the next year a few new ones, and so on. In this way the child will have a knowledge of quite a list of trees or flowers when he is through with the eighth grade. But this can only be done by the different teachers agreeing among themselves what to teach—generally entirely out of the question—or else by adhering more or less closely to a well-arranged outline, planned by some one who had in mind the requirements of the whole course. Where there is a supervisor of the nature-study, or where the superintendent makes such a course, nature-study is generally efficiently taught. Unfortunately, there is not enough such supervision. We would not think of teaching our arithmetic without organizing it into a graded course. Tradition and long experience with this subject have evolved some kind of system in it, and it has been formulated into text-books. Nature-study is still in the transitional stage, largely unorganized and not taught with a book. Of course, this is in a measure an advantage, but it makes it difficult to get definite results. The course presented here is a contribution toward the organizing of this great mass of nature material. It is a suggestion rather than a solution.

We have an embarrassment of riches in nature-study, and the problem in making out a course is as much one of elimination as one of selection of material. The guiding principles in the selection of this course have been the natural interests of the child in his home and neighborhood environment, the social motive, and the principle of correlation. The nature-work is closely correlated with geography. In fact in the primary grades no attempt is made to distinguish between the two subjects. Likewise, much of the nature material suggested is also historical, for example, the life

of primitive man. The relation of nature-study to manual training and domestic economy is also kept in view. Furthermore, one science is correlated with another, physiology with chemistry and physics. In the primary grades, especially, the nature material should be used chiefly for developing the child's expression. Hence the nature-study in these grades is selected largely for its suitability as material also in reading, construction, and art.

It is not expected or intended that all of the topics indicated in the following course shall be studied in any one school. It has been made extensive with the idea of allowing teachers a greater freedom of choice according to local conditions, and also to provide for variety from year to year. The educational motive and the educational material in a commercial metropolis must necessarily differ considerably from those of a rural, agricultural community. In one the commerical industries and civic problems are the chief interest. In the other the chief interest is how to grow plants, and how to raise animals. The course below contains enough suitable material for schools of both communities. Each should select from the course according to local requirements.

The departmental plan of teaching is practised in many of our schools. It might be very desirable in some schools to let the nature-study be taught by certain teachers especially enthusiastic in that work, and especially well equipped for it.

Field lessons and visits to industrial establishments should accompany the nature-work whenever possible. They are not always indicated in the course, but are to be taken for granted. Suggestions for art treatment are indicated by asterisks.

A carefully selected list of books especially adapted for primary reference will be found in the appendix. They are arranged by topics, and the whole group is referred to by letter in the outline of the grades.

Following this in the appendix is a general reference list arranged by subjects. The books are all numbered and are referred to in the outline of the course by number. The teacher should also refer to other volumes of the same class beside those especially mentioned. Often books just as good as those specified will be found in the same list.

Outline of Course of Study

FIRST GRADE

Aim and Method: In this grade the nature-work is not so much for the sake of imparting information as for training the senses, a basis for the work in language, reading, art, and hand-work. The study of the occupations and primitive life is to furnish a basis for the future work in geography, history, and literature. A very important thing in this grade is to develop an attitude of interest in nature and a sympathy for animals, flowers, etc. The beauty element in nature-study should here receive much consideration. The course begins with the common things in the home, garden, fields, and streets of the child's neighborhood.

The subject should be presented here with much more informality than in upper grades. Informal talks by the teacher, simple observations by the children, with some direction of their observation by the teacher, telling by the children the things that they notice, and the free conversational method should be the character of the presentation. Field

lessons should be frequent. The garden, fields, shops, and tradesmen should be visited. The topics should be selected for their timeliness and for correlation with other subjects. The work will naturally follow closely the changing seasons, and should be extensive rather than intensive. Hence the variety of topics suggested.

Do not expect too minute description of details of structure. This should not be very prominent in the lower grades. Do more with habits, beauty, and uses. Do not expect much reasoning out of adaptations, classifications, etc. Do not go much into the reasons for things. The personification of animals, plants, and even inanimate things is here permissible in moderation. Anecdotes are very useful. In the correlated reading, nature myths and fairy tales may be used, but not to excess.

For suggestions as to art application of the topics see p. 57. The asterisk indicates subjects suitable for art treatment. Letters refer to lists in Primary Reference, p. 511. Numbers refer to General Reference List, p. 521.

Throughout the Year

Industrial: Home occupations.* Food Supply (Primary References P, N, S, U). Clothing (S, U). Shelter (S, U). Develop the need for these things, how and where we get them. Who makes them for us. Visit sources. Primitive life (U). Picture child's condition if left to provide his own needs; what he would use in primitive conditions and how he would get them. Describe life of primitive man.* Fire (S, U). Visit garden (Q), farm*, (R, P) and stores* (S) and note articles of food and clothing. Make models of these places.

Weather Study: Have the children note the seasonal changes (X, V), and the effects upon the landscape * (X, L, poems). Note the effect of frost and of warm weather on the garden vegetation, trees, etc. and upon animals. Note migrations and hibernation (X_3, E, L, I, P). Observe the preparation of the farmer for winter, his winter and his spring work (R, P, X); his benefits from the rain, sunshine, warmth, etc.

Effects of heat and cold on water (V, X), experiments. Observe and talk about clouds,* rain,* snow,* sunshine (V, X). Make a sunshine and cloud chart in colors, but do not keep up too long. Talks about the wind* and what it does (V, X). Learn directions (V, X). Make windmills, vanes, and kites.

Talks about what the sun gives us — heat and light (V, X, Y).

Hygiene: Simple talks on cleanliness of hands and face, hair, teeth, nails. Clothing materials. (Z, S.)

Autumn

Animals.

Mammals: Keep children's pets, such as dog, cat,* squirrel,* in the school-room. Let children watch them and take care of them. Tell anecdotes. Study habits and simpler points of structure. Develop the kindly feeling of the children toward pets and wild creatures. (C).

Wild squirrel, in connection with nuts.* Observe outdoors. Feed. Study habits. (B, E).

Birds: Observe and study habits of canary,* robin,* and blackbird (H). Migration (Gen. Ref. 108, H.) Food (H, 120). Habits, (H).

Chicken * and turkey * (G). Observe, feed, talk about uses, especially about Thanksgiving Day.

INSECTS: In the garden and fields observe butterflies and moths. Find cocoons in sheltered nooks, on fences, houses, and bark of trees. Observe caterpillars on milkweed, cabbage, and trees. Collect some of these and keep in cage. Feed proper food. Observe spinning of cocoon. Keep cocoons till the moth emerges. The milkweed * and cabbage * butterflies, if taken early at the beginning of the school year, will perhaps emerge in a week or so. But later they will not come out till the next spring. Gather cocoons * of cecropia moth, etc. and pin up in the school-room. They may open in early spring. (J. K7; See Gen. Ref. 127, 128, 134, 47 143.)

Observe outdoor habits of cricket, grasshopper, fly, and spider. Cage the insects, feed, and observe. Note general appearance and peculiarities. Spiders make interesting school-room pets. Teach children not to be afraid of insects and spiders. (J. also 143, 132; 129; for spider, 130a, 131.)

PLANTS.

FRUITS AND VEGETABLES: Make a study of fruits,* nuts,* and vegetables,* more from the human point of view as to edibility, than from the botanical. Observe them growing, gather some. How do we keep them? Where do we buy them? Where do the storekeepers get them? What use do we make of them in the home, and how do we prepare them? Learn the names of the common kinds. Visit the school-garden, a truck-garden, stores,* the market, the orchard,* and vineyard. Go on a nutting picnic.* Observe at same time the orchard insects and birds, and the animals

of the nut grove. The work should be a preparation for the observance of Thanksgiving Day. (Fruit: N, S, 238, catalogues of nurseries. Nuts: N, S, 220. Vegetables: P, S, R, garden catalogues.)

Trees: Studied for identification, for their beauty, changes with the season,* fruit, benefits. (L. N, 173, etc.) Hard maple,* oak,* elm, chestnut.* Observe the leaf colors,* the beauty of masses of foliage. Pick out the various colors. Try to associate them with particular trees—especially the maple and elm. Collect leaves to use in art work. Observe the landscape during the waning season, and note the changes, the beauty in each aspect. (L, X9, 216.)

Flowers: Visit the school garden and note the kinds still in blossom, learning the names of the commoner kinds. Note fragrance and beauty. Collect, and arrange bouquets. Gather the autumn sunflowers,* asters,* daisies,* golden-rod,* and dandelion.* Learn their common names. Note the abundance of these wild flowers, and the masses of color they produce, their beauty in their natural situations. Gather bouquets for school. Observe them going to seed—dandelion. Blow off the fruits, see them sail.* Collect other seeds that sail—milkweed,* thistle.* (M, N.)

Winter

Animals.

Mammals: Milk and meat (S, T), the dairy (R, T). Visit a barnyard, observe the feeding, etc. of the cows * and calves. Go into the barn and note arrangement for the care of the cattle. Visit dairy, note milking, cans, etc. Study the benefits we derive from the cow—milk, meat, leather, butter, cheese. Simple study of how these things are

prepared and brought to us. Visit meat market. (D, R, S, T, U).

About Christmas consider the deer.* (F, U.) Where found, food, fleetness, enemies, hunting (U). Visit zoölogical garden or park where deer are kept. Rabbit.* Have a tame rabbit in school, feed it and care for it. Make a hutch for it. Observe its general appearance, color, hopping, feeding. Let children be on the lookout for wild rabbits, and tell their observations. (E, C.) Note the fur.

Examine the fur garments of the children. What kinds of furs are represented? Tell about trapping and hunting, (S, U) fur animals. (E, F.) Sheep,* chiefly in its relation to clothing. Observe sheep if possible. Show wool on the hide, shorn wool, spun and woven, and dyed. Refer to the warmth of furs and woolen clothing, (D, S, T, R, U.) Refer to primitive man,* and discuss his food and clothing. Refer to the Indian. (U, W.)

Birds: Note that all the birds have not flown away. On field trips, and incidentally, let the children observe the birds. By color charts teach them to recognize the blue jay,* nut hatch, chicadee,* and the English sparrow. Note their beauty, cheerfulness, the sounds they make, their food, where they stay at night. (H.) The sparrow is especially easily observed about the school and homes, and everywhere on the streets (120). The scarcity of food in the snow-covered fields brings many of the wild birds into the towns, where they may be fed and made less wild. Let the children show their sympathy for the birds by feeding them crumbs, etc. (See chapter X.) (113, 478.)

Fish: Have goldfish * in an aquarium. Let the children help take care of the fish. Observe the beauty and grace of

the fish in swimming. Note feeding. Note general shape, etc. (I.) Fish as food. Brief talks on fishing. Primitive man's methods of fishing. (I, U, T, also 46, 49, 42.)

PLANTS.

GARDENING: Planting bulbs of tulip * and hyacinth.* Care of potted plants and window-boxes. (235, 224, 229, 221.)

TREES: Note the winter landscape,* the bare trees.* Observe the oak and elm, and try to see general typical form of each, and identify. (L.) Observe the contrast of pines * and balsams * (L, 173, etc.) with the other trees. Note characteristic shape, mode of branching, needles * and cones,* and resinous nature. Note their beauty, frosted and laden with snow. Collect cones and twigs. Especially appropriate near Christmas.

SPRING

INANIMATE.

SPRING WEATHER: Greater warmth, melting of snow and ice, awakening of vegetation and animals, the March wind,* clouds,* rain,* running-water, the brook *—field lessons. (X. V.) (See Weather above.) What the wind does for us. Make windmills, kites, vanes. What the rain is good for.

THE BROOK: Where does the water in the brook come from? Note its swiftness, how it carries things along. Make toy boats to float upon it. Note the quiet pools, the little falls, the round pebbles—gather some. The beauty of the brook.

ANIMALS.

BIRDS: Identify the returning birds, (H, 95, etc.) Let the children vie with one another in reporting new arrivals.

In field lessons observe and identify. Note habits, song, food, nest building,* eggs,* care of young. Emphasize the beauty and song of birds. Try to have children associate songs and calls with particular birds. (108, 111, 112, 120, 478, 113, 109.) List: Crow,* robin,* blue-bird,* blackbird, redheaded woodpecker.* (110.) Let the children put out bits of string, hair, feathers, etc. for the robins, sparrows, bluebirds, and wrens. Teach boys the wrong of robbing nests, stoning birds, etc.

Have hen and chickens * at the school. Let children care for them. Observe parental care of the old hen. Food. Visit a poultry yard, and note different kinds of chickens, etc. Note the beauty and the crowing of the cock. What the hen gives us: Eggs, meat, feathers. Why does the hen scratch? How should we care for chickens? (G, S, R.)

Frogs: Take the class to a ditch or pool where there are frogs' eggs. Observe where they are placed. Collect some and place in jars or aquaria—only a few in a jar—and let them hatch and develop. The children should make informal observations of the changes.* Have a frog in a vivarium, (24). Feed it worms and insects. Observe how it eats. Care for it. (I.)

Earthworms: When the frost comes out of the ground observe the return of earthworms. Collect some, and put in a worm cage and feed. Observe. (B.)

Insects: Visit a hive, and observe the bees at work. Better still if an observation hive is accessible. Observe bees in the flowers, laden with pollen. Simple study of the form of the bee, its social life, and honey gathering. (J, 144, 133.)

Observe an ant-hill, noting numbers, cocoons, feeding,

working, Prepare an ant cage (Chapter XIV, 47, 126, 481) and feed, and observe in the school-room. (J, 136, 132.)

PLANTS.

TREES: (L, 173, etc.) With the children gather pussy-willows,* and place them in water in the school-room. Force buds of horse-chestnut,* lilac, maple. Observe the unopened buds and follow the changes. Note the changes in the landscape owing to the growth of grass and tree buds. Trees have flowers: Apple,* plum,* willow, oak, maple, lilac.* (L, 175, etc.) Identify the trees studied in the fall and the new trees mentioned. Teach that fruit and seed come from the flower. Observe this in the plum, apple, etc. Thus there is use as well as beauty in a flower. (K, L.) Plant apple seed, acorn, maple fruit, etc.

GARDENING: Make window-boxes, prepare soil, and plant Lima beans, peas, corn, grain, flower seeds. Teach proper way of sowing, or planting, watering, etc. Try to note conditions necessary by withholding water and heat from some of the seeds, and note that seeds fail to grow. Observe the growth of the seedlings,* how they cast their skins, etc. Make a simple glass germinator (chapter XVII) and show how the seed swells, bursts, and how the little plant emerges. Make study simple and observational. Plant acorns, plum pits, apple seeds, maple fruits, and try to cultivate them to set out later. The flower seeds also may be started for later transplanting out in the school-garden. (K, Q, 221, 222, 229, 234, 235, 237, etc.)

The School-Garden: This grade should have a plot of its own for a class, or group beds. The heavier work of spading, fertilizing, and raking should be done by the

upper grades or some one else. Let the children take an active part in the selection of seeds and the planning of the beds. Let them mark off the beds for different crops, and do the sowing or planting as far as they are able. Sow early vegetables such as lettuce and radish. Later, when safe, transplant the nasturtium, sweet peas etc., started in the window-boxes. Plant pumpkins and popcorn. Perhaps lay out a miniature farm with different grains. (See Chapter XVI.) The children should do the weeding, watering, training, etc.

SECOND GRADE

Aim and Method: These are practically the same for this grade as for the first. The children are now able to express themselves better, and more can be got from them in descriptions, oral and written. Drawing can also be used more in this grade. More may be done with the relations of animals and plants to their surroundings, and to each other, and something with the observation of the operation of inanimate forces. The plants and animals identified last year should be reviewed briefly, and new lists added.

Suggestions for art-study in connection with nature-study—see p. 57. The asterisk indicates subjects suitable for art treatment. The letters indicate primary references, p. 511; the numbers, general reference list, p. 521.

Throughout the Year

Industrial and Geographical: Clothing, materials used, from what animals or plants derived, how prepared. (S, T, U.) Chiefly in connection with the proper topics below. How our houses are built, the materials used, and the trades employed. (S, T, U.) Compare with primitive

man. Picture him under primitive conditions providing his necessities.* (U.) Fire, how kindled, uses, primitive method of making. (S. U.) Take up in winter.

Domestication of animals, how brought about, benefit to the race from this. What animals were tamed. (U, D, 60.) Uses: Skins, leather, meat, milk, as beasts of burden. (S,T, U, R.) Nomadic * and pastoral life,* illustrated by description of the life of children in other lands and times. (U, W, R, V.)

Modes of travel, routes determined by natural features, idea of trade and transportation of commodities. (U, V, W.) Rural and city life, illustrated largely from childhood life. Point out some of the advantages and pleasures of each. (R, V.) Children in other lands. Idea of climate and notions of geography. (W.)

WEATHER: Seasonal changes in temperature, etc. (X, V.) Changes produced in the landscape,* note varying beauty, colors. (X, L.) Effects on plant and animal life — the preparation for winter, ripening of fruits and seeds, falling of leaves,* migration of birds, hibernation of frogs and other animals, the winter sleep of trees, the awakening, flow of sap, bursting buds, return of the birds, and awakening of frogs, etc. Farmer's work* in different seasons. Fuel and clothing, and the weather. (X, K, I, B 6, R, V.)

Learning to read the thermometer,* freezing and boiling points. Experiments to show evaporation, condensation. (X, V, 250, etc.) Observe clouds,* rain,* snow,* ice, frost * on the window, wind,* when these phenomena occur. Discuss their effects, their relation to child sport,* the uses of each in nature, and to man. Personify them to bring out their active character as natural forces. Apply the experi-

ments in physics to their simple explanation. (X, V, 327, 328, 326.)

Keep weather charts for short intervals at different seasons, recording temperature, wind direction, cloudiness, rain or snow, sunshine, the children making the observations, and record. Associate certain kinds of weather with certain directions of the wind. (X, V, 10.) In connection with weather study develop the idea of climate—cold, hot, dry, moist, reading stories of child life in other parts of the world. (V, W.)

EARTH-STUDY: In connection with house construction study building-stones, the kinds used, where they come from. Observe if possible boulders in the fields, ledges of rock, quarries, and visit a stone cutter, or observe the work on a building under construction. Not much can be expected in this grade in identification of the stones. (S, T, V, 316, 339, 343.) Note other uses made of stones—fences, monuments. Collect specimens, especially polished pieces.

In spring observe the running waters from the melting snow. Study the brook.* Note how it carries along floating sticks, etc., and mud and sand. Observe the muddy rills running into it down the banks and sides of the ravine. Note the channels washed out by the rills. Bring out the fact that the valley of the brook was also formed in this way by the brook. Observe falls, rapids, pools, and sand-bars, but do not go into details with them. Visit a hill. Note difficulty in climbing. Note the broadening of the view. Note how streams and roads go around rather than over. Show how the hills are an obstacle in travel; the ravines, and valleys easy to follow. Visit a lake.* Note its beauty of waves and reflections. Note its location amid hills. Note

the waves, how they dash and chafe on the shore, seen especially well at a bluff. Refer to the uses made of the lake, the childhood sports * connected with it. Visit a river if possible. Compare with a brook previously studied. Observe valley, erosion, sand-bars, etc. Climb an elevation and observe the valley. Note the river winding through it. Discuss the uses made of the river in transportation, water supply, boating,* bathing,* fishing,* harvesting ice, etc. In a similar manner observe other earth features—mountain and plain, illustrated if possible by local topography. References: V, 320, 328, 338, 343, etc.

ASTRONOMY: Simple talks about the moon,* stars,* and sun,* their beauty and the benefits derived from them. Note changing length of day. (Y, 388, etc.)

HYGIENE: Clothing in different seasons. How not to catch cold. How to breathe properly. How to sit, walk, and stand properly. (368 etc.)

AUTUMN

ANIMALS.

MAMMALS: The dog.* A sympathetic study of dogs, their friendship and faithfulness to man, their uses as watch-dogs, shepherds, hunting-dogs, and as pets. How we should treat them. Some different kinds of dogs,—show pictures, special qualities. Stories about dogs. What a dog eats. Observe teeth of a pet dog in school. Note lapping of milk or water, gnawing a bone, swallowing a piece of meat. Make a study of a dog's feet. Compare the general appearance of different dogs, note differences. Stories showing the intelligence, etc. of dogs. How does a dog express different moods? (C, 60, 58, 413, 414.)

Squirrel,* chipmunk,* gopher.* Observe, if possible, outdoors. Note the places where they live. If possible note the food they eat, their manner of running, sitting, climbing, their calls, their homes. Storing up food. Winter sleep. Try to tame the squirrels in the parks, or groves near the school, feed them nuts, corn, etc., and do not frighten or injure them. (E, 74, 75, 78, 79.)

Fox * (in connection with poultry): Preying upon poultry, shyness and cunning. Stories about the fox, where he lives, young foxes. What dogs look somewhat like a fox? Make a comparison of the general appearance and the habits of dogs and foxes. They are "relatives." (F, 61, 67, 37, 25.)

Birds: Ducks * and geese.* Visit a duck-pond,* or poultry yard, and observe the swimming, dipping, feeding, waddling of these birds. Note their sounds. Feed them. Observe their bills, feet, wings, feathers. Do they get wet in the water? What are they good for? Refer to wild ducks and geese, and their domestication. The fox enemy. (G, R, S.) Care of poultry.

The "chicken" hawk: Observe flight, soaring. Food of hawks. All hawks are not injurious, most of them do good. How? (H, 99, 120, 100.)

Eagle: Pictures and stories. Home, nest, food, preying, soaring. Compare the pictures of a hawk and an eagle. Note the curved bills, the long curved claws. Hawks and owls are "birds of prey," or "robbers." (H, 120, 100, 68.) Associate the eagle with the U. S. flag, coins,* etc.

Migration of birds: Observe the great flocks of blackbirds. The gradual disappearance of other birds. How long do the swallows stay? The robins? Give some idea of the lands to which the birds go by reading stories of those

regions, their climate, vegetation, etc. Show pictures. Why do the birds not stay? Do all the birds fly south? (H, 108, 100, W.)

Insects: Life history of butterfly and moth: Observe caterpillars of milkweed, and cabbage butterflies in field, also find caterpillars * of cecropia moth, the wooly bear, etc. Cage and feed them. Observe spinning of cocoons, and, perhaps, if not too late in the season, the emergence of the milkweed and cabbage butterflies. Be sure the children see that the caterpillar is only the baby moth or butterfly. Note general plan of a butterfly. Note its beauty, graceful flight, its feeding on flowers.* Collect cocoons,* note where they are found, bring them into school, and keep them till spring when they may open. (J, 129, 130, 136, 134, 149, 150.) Send for eggs of the silkworm (see chapter XIV) and try to rear them through the life cycle.* (See last references, also W, T, S.) Brief study of silk. Try to unravel cocoon.

Observe grasshoppers * in field and cage. What do they eat? How do they use their jaws? Note head, chest, abdomen with rings, wings, legs, especially the last pair. Observe the jumping and flying. Catch crickets and keep them in the school-room. Hear them chirp. How do they do it? Compare them briefly with grasshoppers. What are their habits? Study beetles as to their hard shell, the harm they do (potato-beetle). Find ground beetles. Study flies and mosquitoes briefly as troublesome pests. Dragon-fly *: Beauty, swiftness, and grace in flight. Common names, uses, not dangerous. Observe the gauzy-veined wings, iridescent eyes. Found generally near the water. Bees: Observe general appearance, note buzzing flight, feed-

ing among the flowers, pollen baskets on the legs, pollen dusted on their hairy bodies. Compare the bumble-bees * with them. Bumble-bees may be kept in a cage and fed with honey or sweet water. Also observe the wasps * on the flowers or on the windows. Do they resemble the bees? How? How different? Collect wasp nests * and open one. Note the paper walls, cells, larvæ. Compare with bee comb. (J, 129, 130, 136, 132, 47, 137, 15, 33, 34, 146.)

SPIDERS:* Observe outdoors, webs, spinning, catching insect, beauty and symmetry of web. Have a school-room spider. Observe, feed. Teach children not to fear spiders. (J, 130a, 131, 47.)

FROGS AND TOADS: Have children find and bring them in. Vivarium. Care, food, water. Habitat of frogs, food, uses. Enemies. Feed the toad * worms and insects; observe how it licks the food up. Observe burrowing. Can you easily find it when partly buried in soil? Why? Toads do not cause warts and are not poisonous. What are they good for? Do not kill frogs and toads for the "fun" of it or because you think them harmful. (I, 24, 33, 34, 47, 26.)

Aquarium stocking: Collect water insects, crayfish, minnows, clams, snails, and keep in aquarium. (See page 165.) Use for informal observation. (47, 33, 34, 93, 1.)

PLANTS.

GARDENING: Visit the school or other garden. Observe the effects of drought, weeds, and insects. Observe the latter. Collect bouquets * and arrange artistically for the school-room. Train up vines, pull or cut weeds, and get garden in as good condition as possible after the summer's neglect. Later, gather vegetables and seeds. Put seeds into

labeled packages for sowing next season. Later, observe the effect of frost on flowers and vegetables, protecting some. Which are the least hardy? Which hardy? Plant fall bulbs,* (tulips) and mulch them for the winter. (229, 221, seed catalogues.)

HARVESTING: Garden vegetables,* kinds, uses, storage. Visit school, and other gardens. (P, R, S.) Grains: Visit a farm, if possible, observe harvesting,* threshing.* Learn to recognize different kinds of grain. Primitive threshing.* Observe where the kernels grow. Uses of different kinds. Uses of straw. The story of a loaf of bread—briefly. (P, R, S, V.) Collection of different kinds of nuts.* Nutting picnic.* Observe animals there.* (N. S.)

FRUITS: Visit a fruit store.* Note different kinds. Study some.* Edible portion and the pits, stones, seeds. Save these for planting. Preserving by canning, and drying. Beauty, fragrance, flavor, and sweetness of fruit. (N, S, 301, 304, 311, 368, 222.)

TREES: Review those learned last year. Add horse-chestnut, *apple,* pear,* cherry, peach,* walnut,* butternut. Note their general appearance, leaf,* fruit.* Autumn colors, changes,* beauty. Note typical color * of maple, elm, sumach. Observe leaf fall.* Observe wind playing with the fallen leaves.* Note the buds ready for winter.* (L, 216, 161.)

FLOWERS AND WEEDS: Review the flowers learned last fall. Observe the different kinds of wild asters,* sunflowers,* and goldenrods.* Collect for the school-room. Note beauty of roadside, copse,* and pastures. Thistle:* Spines, flowers, seeds. Milkweed:* Pods and seeds, collect for school. (M, K, N.) Make a chart of seeds that fly.* What are seeds for?

What are the sails or wings for? Weeds: Plantain,* dandelion,* daisy,* purslane. What are weeds? Why objectionable? How do these weeds injure? Study them sufficiently to be able to recognize them—root, leaf, flower, seed. Why do the dandelions grow so abundantly everywhere? Examine the lawn for weeds. (222, 228, 231, 240, 156.)

Winter

Animals.

Mammals: Sheep * in its relation to man. Wool, shearing, spinning, weaving, very simply. Clothing. Stories about these processes. Care of sheep. The shepherd and his dog.* (D, R, S, T, V.) Our dependence on lower animals.

The Wolf:* Enemy of sheep. Stories. Strength and boldness. Home. Compare with dog in general character and appearance. The pelt is used for robes and coats. Hunting stories.* (U, 433, 444, 277.) Bear:* General form, fur, paws, strength, food, den, winter sleep. Taming cubs. Stories. (F, 25, 17, St. Nicholas, 435.)

Deer:* Visit deer park or zoölogical garden. Note grace, fleetness, and beauty. Food. Males, does, and fawns. Antlers, shape, growth, uses. Stories of primitive man and Indians hunting the deer.* Hiawatha.* (F, U, 69, 68.)

Birds: (H. 113, 109, 478.) Those that stay. (See Winter, First Grade, same birds, and same treatment.) Add hawks, owls,* doves,* downy woodpecker,* and snowbirds. Identification study of these both in school and out. Feed the birds on the school ground or at home. Learn about the habits of owls, their homes, food, beaks, bills. Owls belong with the hawks to the "robbers" or birds of prey.

FISH: Keep aquarium. Goldfish,* minnows,* etc. Feed. Observe the swimming, feeding, breathing. Use of tail. Colors, scales, fins. Fish shape, compare different kinds. Discuss fishes as food, fishing,* primitive man's method. (I, 15, 33, 34, etc., U.)

PLANTS.

GENERAL: Outdoors observe the winter aspect * of deciduous trees. Try to identify those learned in the fall in foliage. Note the characteristic branching.* (L, 173, etc.) Compare the evergreens * with the last. Note their beauty, shapes, needles,* cones,* resin. Study the cedar, cedar-wood. (L, 173, 220, etc.)

Discuss winter condition of buds, roots, bulbs,* seeds—"sleeping," protection from the cold by the snow, leaves, etc. Bring in some lilac, plum, willow twigs, and try to wake them up, placing them in water. (K, L.)

Flax and Cotton: Show in natural form, discuss in simple way the general process of getting the fibre, spinning, weaving, dyeing. Examine and distinguish cloth made from these fibres. Other uses of cotton. Stories of where the cotton grows. Show how we depend upon nature for our clothing. (S. T, V, W.)

GARDENING: Window-boxes and potted plants. Preparation of soil. (229, 221, 235.) Wandering Jew, geranium, primrose are good for indoor culture, also hyacinths * and tulips,* and daffodils.* Plant seeds of fruits, nuts, pits, and try to raise for later transplanting. Butternut or walnut are good. Early in spring or in late winter start seeds of flowers for planting in the garden, also vegetables. Lettuce, nasturtium, pansy, zinnia, verbena are good for this grade. The children

are to do practically all this work, and to have the care of the plants.

Spring

Animals.

Mammals: Sympathetic study of the horse,* showing what it does for us,* and how we ought to care for and treat it. Various uses in the city and on the farm. Observe horses Note different kinds—draught, carriage, race horses, ponies. Visit a farm yard or stable. Observe how the horses are cared for and fed. Their food. Call attention to abuses of horses by drivers overloading, too fast driving, too tight a check, not enough food, etc. Read parts of "Black Beauty." Talks and stories about the intelligence of the horse. Observe how a horse uses his ears. What is the tail good for? Is it right to dock a horse? Note the hoofs. Why do we put shoes on them? Visit a blacksmith or horseshoer. (D, 40, 60.)

Birds: (H, 95, 96, 100; 107 to 125, 478.) Identification study. Review the spring birds learned in the first grade. Meadow-lark,* catbird, wren,* oriole,* bobolink,* martins. Observe these and learn about their ways. Return of the birds. Make a bird calendar. Observe the wild ducks and geese, robins,* blackbirds, etc. as they come back. Note their songs and calls, try to identify by these alone. Emphasize the beauty element, and develop sympathy for birds, a desire to help and protect. In the nesting time hang up hair, wool, threads, feathers, etc. for wrens, sparrows, bluebirds, etc. Observe the birds at work on the nest.* Eggs.* Observe but do not steal. Observe young, feeding, solicitude of parents. Protect and feed young birds fallen out of the nest, perhaps taming them, but not keeping them in

cage permanently. Set out at school or home a drinking trough. (Attracting birds: Chapter X, 113, 109, 478. Food: 120. See page 124.)

Insects: Observational, informal lessons on June beetle, ground-beetle, potato-beetle, butterflies (when do they first appear?), cecropia moths * (observe the school cocoons). Insects on the flowers (willows, maples, hepaticas, pasque-flowers, etc.) Visit a beehive, and note the renewal of activity. (J, K, 156, etc.)

Frog: Observe the first pipings of the frogs. Refer to their winter sleep. Find eggs of frogs and toads. Make informal observations on the aquarium tadpoles,* fish, insects, etc. Observe tadpoles in the pools at different times in the spring. Do not injure frogs, and especially toads. Pick up toads and place them in your garden to catch grubs, etc. Tame one, feed it. (I, 24.)

Plants.

General: Study of whole plants* (see spring flowers), briefly referring to use of root, stem, and flower. (K, 156, 158, 161, 222.) Observe the insects on the flowers, (K, M, 156, etc., 207, 216.) Simply refer to their getting nectar and pollen, but omit the pollination. Let children taste the nectar in the spurs and tubes of the columbine, honeysuckle, sweet pea, etc. Rub from marsh marigold, roses, etc., some of the pollen, and note its powdery nature.

Trees: Identification study. (L, 173, etc.) Review trees learned in the fall. Observe the bud development.* Force in school. Observe the flowers of the plum,* apple,* willow,* poplar, maple.

Special study of the sugar-maple.* Sap. Collect sap

and make syrup and sugar. (L, S, T, 220.) Uses of trees for fuel and lumber, nuts, fruit, sap, etc. The story of a pine board—very simple. The Carpenter.* Observe at work. (L, S, T, 220, 219.) Characteristic form and branching of different trees.* Trees in masses,* their beauty, landscape effects.* Observe changes * in forest or grove with the advancing season. (L, 216.)

FLOWERS AND WEEDS: Review those learned last spring. Add pasque-flower,* wind-flower,* columbine,* violets,* Dutchman's breeches. Weeds: Dandelion,* plantain,* purslane. (M, K, 168, etc., and for weeds: 222, 228, 231, 230.) Let children collect, observe where the flowers grow. Do not waste. Make a simple study of characteristic features of flower,* leaf,* stem,* and root.* Learn the parts * of a typical flower. Observe the development from flower to fruit *—apple, plum, dandelion. Purpose of flowers. The pleasure we get from them. Insect visitors—see above. Press the flowers studied, and make a decorated booklet, with brief description of place, appearance, etc., arranged in the order of time of flowering.

GARDENING: Germination studies.* (See chapter XVI.) Note conditions of moisture, and temperature necessary. Try to raise some seeds without water and without warmth. Make glass germinators, and observe the behavior of the seedlings * in coming out. Plant seeds in sawdust or, better, in soil, and observe later stages of the seedling. Peas, beans, corn, grains, squash, sunflower, radish are good. Get fresh, seasoned seeds. (K, 156, 154, 190, 196, 222, 228, 231, etc.)

School-garden: Make class or group beds.* (Q, 237, 234, 240, Chapter XVI, 481.) Perhaps lay out a miniature farm * with different crops, vegetables, and flowers. The

coarser work of spading, etc., to be done by upper classes or some one else. This grade to select seeds, and have a part in planning the garden. Let them mark off the plots, sow and transplant, water, weed, etc. Teach right methods. (221, 229, 240, 222, etc., seed catalogues. For flowers and vegetables in this grade see page 295.) Transplant seedlings started in school. Begin a tree nursery. (220, 240.)

Dig up and transplant, in borders, school-garden or window-boxes, wild flowers—hepatica, bloodroot, columbine, violets, etc.

Encourage the children to help their parents in the making of home, flower, and vegetable gardens.

Remove the mulching from the tulip beds.

THIRD GRADE

Aim and Method: While these are, in the main, the same as in the first and second grades, the children are now older and are capable of more observation and reasoning. They are more interested in the practical application of their knowledge, hence they should be taught more of manual training, geography, and hygiene. Though field work should be continued as much as possible, more indoor study can be made, relying somewhat upon previous observations and experiences of the child, and using pictures to a greater extent than before to represent the thing studied. But the actual object should be used whenever possible as the basis of the lesson. More can be done with the direction for preliminary observations by the children. Less familiar types may be studied. The principle of variety need not be carried so far as in lower grades, and there may be more of a se-

quence in the lessons. Causal relations, adaptations, and comparisons, and grouping can be worked out a little more. The method of presentation, although it should still be somewhat conversational, should be more formal. The collecting instinct may be utilized, and the sympathetic attitude toward nature should be preserved and extended to an active protection of birds, flowers, etc. Develop the æsthetic appreciation of nature. The work of this grade is immediately preliminary to formal geography, hence the geographic element is emphasized. The nature work may be aided by written tasks, drawing, painting, etc., and by supplementary nature readers.

For suggestions for art-study in connection with nature-study, see p. 57. The asterisk indicates subjects suitable for art treatment. The letters indicate primary references, p. 511; the numbers, general reference list, p. 521.

Throughout the Year

Industrial: Review briefly our chief needs and the sources of food, shelter, materials, clothing. Study of textile art.* Make a study of Indian life—Hiawatha.* Apply the above. (U, S, N.) Discuss division of labor and trades, origin and advantages. (U, T.) Domestication of animals, advantage over hunting and fishing. Planting of crops, advantages. (D, U, 60.) Shepherd life* (Arabs, early Jews). (U, V, T, 60.) Agriculture and man, origin, advantages of the farmer, dependence of others upon him. (U, V, T, R.) City life,* stores, transportation, lighting, etc., briefly considered. City industries. Relation of the city to the country. Commerce. (V, T.) Stories of people in other lands to give idea of different climates, products, and modes of living. (W, V.)

EARTH-STUDY: Home geography, land and water forms, the lay of the land. School-yard drainage. Brook study:* Erosion, sediment, deposits, falls, rapids. Apply to river. Observe uses of the river.* Study of valley in relation to transportation, settlement. Weathering of rocks and soil formation. This should all be studied in the field. (V, 326, 327, 328, 335, 337.)

Earth water: Source. Springs and wells. City water supply. Purification from sediment (experiments.) (As last, and 263, 269, 264.)

Clay *: Properties and uses, where found. Visit clay bank, brickyard. The making of bricks. The mason.* Observe masons at work. (T, S, V.) Coal: Where does it come from? Uses in home, engine, factory, smithy. A little about a coal mine. The miner. (V, T, 348, 330, 337.) Common metals: Learn to recognize. Simple experiments on their elasticity, hardness, etc., and illustrations of their uses. A little about primitive man before and after his discovery of the use of metals. Go about the schoolroom and find articles made of metals. Make a list. Do the same at home, naming the metal used. (V, U, T, S, 263, 269, etc.) Table salt—the story of. (V, 263, S.)

WEATHER: Seasonal changes, effects upon landscape,* plants, and animals. (A, 6.) Study of moisture in the air, clouds,* rain,* snow,* frost crystals, ice.* Illustrate as far as possible by simple experiments in physics. Note the beauty of each phenomenon and the benefits we derive from it. Also show the benefit to plants and animals. Learn the use of the thermometer,* the freezing and the boiling point. Keep a record of cloudiness, rain, wind, and temperature for a short time each season. Which wind brings the

cold, etc. Learn directions. (X, V, 327, 326, 328, etc.) Connect with nature myths.*

ASTRONOMY: (Z, V.) Sun's rising and setting, position and times in different seasons. Length of day, noon shadow, day and night. The north star, how used? How found? Big and Little Dippers, and other simple constellations. The beauty of the stars. Read star myths.* Brief reference to the phases of the moon.

PHYSICS: How we heat our buildings. Kinds of fuel used, sources. (S, V.) Stoves, fireplaces, furnaces, hot water and steam—very simply explained, mainly the construction. (258, 250, 257, etc., S.) Primitive method of heating. (U.) Other uses of fire. (T, S.) The thermometer, parts, scale, uses. (251, 250, 257, etc.) Cooking. (Z, 304, 303.) How our homes are lighted. Compare with primitive man. (U.) Simple study of candle,* lamp,* electric and gas light. (S, T, 250, etc.)

Experiments in evaporation, and condensation of water, melting and freezing. (V, X, 251, 250, 257.) Make crystals of alum,* salt, and sugar from solutions, by cooling and evaporation. Show crystals of sugar and salt under a reading lens. Show crystals of quartz; examine snow crystals * in a storm. (V, T, 251, 250, 257, 263, 268.)

Make a simple study of the magnetic compass * and learn to find directions with it. (V, 251, 250, 257, etc.) Use on the ocean.

HYGIENE AND PHYSIOLOGY: What we eat and drink. Should be pure and clean. The refrigerator—what we keep in it, why? (S, N, O, P, Z.) What teeth are for, different shapes and uses. Why we should chew well. Care of the teeth. Cleanliness, bathing. Proper clothing. Avoidance

of colds. (S, T, Z.) Simple talks on our muscles and bones, what they are for, and how to use them properly. Good sports and exercise for children. Reading and writing posture and hygiene. (Z, 368a, 372, etc.)

Autumn

Animals.

Mammals: Detailed study of sheep * and goat * (D, R, S) from the economic point of view, especially. Some study of structure, covering, horns, hoofs. Observe if possible in pasture * or barnyard. Domestication. (U, O.) Shepherd life.* (U, R, V, T.) Shearing, cleaning, spinning, weaving, and dyeing (the story of a dress or coat). The weaver. Brief study of the development of the textile art. (U, S, T, V.)

Birds: Observe the habits of the birds in the fall. Recognize those learned last spring. Observe the migration. Note when certain species, the barn swallows, for example, leave. Some reasons for their going. Observe the blackbirds in the fields. What does the farmer think of them? What do the swallows feed upon? Where are they generally to be seen? Why? Learn to recognize bobwhite,* thistle bird,* humming-bird.* Observe habits of each and its food, if possible. (H, 95 to 106 for identification and habits; 100, 108 for migration; 120, 246 "Some common birds" for food. See page 119.) Have a canary * in school. Let the children have the responsibility of its care. (C.) Collect old nests and label them if known.

Insects: (J, 126 to 151, also 47, 33, 34, 18, etc.)

Life histories: Review rapidly that of the milkweed butterfly * and the cecropia moth.* Try to raise the cabbage caterpillar to maturity. Collect cocoons, and hang up to

observe in spring. (127, 130, 134.) Make a study of the life of the dragon-fly.* With the children collect large nymphs of the dragon-fly in pools and ponds. Keep in aquarium. Feed with mosquito wrigglers, small water shrimps, etc. Observe the habits of the nymph. Some of the nymphs may be observed emerging from their skin, a very interesting sight for the children. Observe the wings of the dragon-fly when first out, then the expansion. Observe the actions of the adult. Uses. Mosquito wrigglers may be observed in a similar manner to develop to maturity. (135.) In the above insects the babies do not look at all like their parents, but change marvellously in their growth. Find young grasshoppers without any wings. Compare them with the adults. Here the babies resemble the parents from the beginning.

A little structure study. The locust:* Principal parts of body, wings, legs. Observe the mouth, the eyes, the feelers. Unfold the wings. Note their beauty and their veins. A beetle:* Chief characteristics—hard wing covers, find delicate under-wings. Observe lady-bugs* flying or tucking away their wings. Note hard shell on the outside of the whole body. How many legs do beetles have? Grasshoppers? Dragon-fly, adult: General shape of body, rings on abdomen. Where are the legs and wings fastened? How many legs? How many wings? How many has the grasshopper? Note the gauzy, netted wings, observe flight. Note the big eyes, the pretty colors that play on the eyes, the colors of the body and wings. Do not fear the dragon-fly. It is harmless and useful (why?). Butterfly: Great wings, beautiful colors. Note the powdery scales that come off, the hairy body, the knobbed feelers. Unroll the trunk with a pin. Observe a butterfly feeding. (J. 47, 15, 24, 33.)

Visit a hive,* an observation hive, if possible. Observe the great number of bees. Observe them at their work. Note the pollen baskets on the returning bees. Observe them collecting nectar and pollen from flowers. What insects do we not like? Which bite us or sting? What insects are troublesome in the house? Why? Examine the leaves flowers and fruit, in the garden or orchard. See how worm-eaten or injured they are by insects. Note the effects of the potato beetle. Examine wormy apples. Find the little caterpillar of the codling moth in the apple. Many insects do us harm or eat our crops, etc. Make a list of those observed. (148, 132, 136.) Collect with the class pond insects—whirligig beetles, water boatmen, water striders, water beetles, larvæ of dragon-flies and water beetles, electric-light bugs, etc., also other pond creatures—crayfish, clams, snails,* etc., and put them in different aquariums with pond plants, and make simple informal observations on them. Keep goldfish, minnows, or other fish.* (For keeping aquarium see page 165, also reference No. 47, 130, 126, 93.)

Miscellaneous: Keep lizards,* toads,* turtles.* Observe. Refer to hibernation.

Plants.

Gardening: Put garden in order after the summer's neglect. Observe the harm done by insects, drought, and wind. Collect flowers for school-room decoration.* Collect the vegetables, etc. Collect seeds and put up in labelled packages for next year. Give seeds away to those who have none. Have a school-room exhibit of the things raised in the school-garden. Set out bulbs (tulips, crocus) for spring. Later, observe the effects of frost on different plants. Protect such

as are desired to save a while. Later, clean up the garden for winter. Mulch the bulb bed. Protect the seedling trees. (Chap. XVI, 229, 221, 240, Q.)

GENERAL: Gather garden products from school-garden. Study them from the economic point of view. (P, R, S.) How kept in the winter. How prepared for table. Special study of the potato.* Dig up and see how the tubers grow. Importance of potato as food. Simple study of starch. Try to make starch from grated potato. (P, S, K, 222, 228.) The potato a storehouse of starch food. What does the potato grow tubers for?

Native fruits * and nuts:* Visit orchard or nut grove. (S, N, R, 238.) Their edibility, beauty. What does the tree grow fruit for? (K, 154, 156, etc.) Find the seed part in different fruits. Plant some seasoned fruit-seeds. Briefly tell the story of an apple-seed—life cycle of tree.

Note the development of flowers into fruit, the formation and the scattering of the seed. Observe and collect seeds that sail,* seeds that "steal a ride," burs.* Make a seed chart of each kind. How the wind helps seeds to travel. How people and animals carry the burs. (N, K, 154, 156, 158, 161.)

TREES: Identification study: Review those learned in previous years. Add pear, beech, hickory. (173, etc., L.) Raspberry, gooseberry shrubs.

Autumn foliage,* landscape effects.* Color changes in particular trees.* Collect, and make booklet with leaves mounted and describing each tree represented, perhaps a painting of the tree in color, and a drawing of it later when bare. Note the buds on the twigs.* What is a bud? (L, 216, K.)

Flowers and Weeds: Review autumn flowers learned previously. Add harebell,* thistle.* Note beauty of plants as individuals and in masses, the colors in the prairies, meadows, copses. Note the going to seed, and the sailing seeds, and burs. Bring in wild flowers to school-room. Dig up roots of wild sunflowers, asters, goldenrods, daisies, etc., and set them in borders or corners of the school ground or at home. (M, 168, etc.) Thistle, burdock, sticktights, bur marigold. Study the burs.* (268, etc., 154, 156, 246 "Weeds.")

Winter

Animals.

Mammals: Fur bearers: Muskrat, beaver,* mink, raccoon, bear.* Study the animals themselves as to general appearance, homes, habits, food, uses. Briefly study the nature of fur. Compare with hair and wool. Why do we dress in furs? Stories of primitive man,* Indians, Eskimo. Examine children's wearing apparel for furs of different kinds—remembering, however, that many trade names of furs are misleading. Stories of trapping* and hunting.* The story of the beaver appeals particularly to children. (E, F, S, 78, 17, 28, 67, 433, 434.)

The Reindeer*: In connection with Eskimo life. Appearance, qualities, uses. (F, W, 23, 26.)

Birds:* Winter residents. (H, 478.) Feed. Observe habits, food, shelter. Make a list of the kinds that are to be seen.

Plants.

Visit a greenhouse and note the temperature, the moist air, and the plants. Conditions are tropical. Many of

the plants there—palms, lilies, orchids, were brought from the tropics. Read about the south-land where the birds are. Describe the climate and vegetation. The fruits that grow there—oranges,* lemons,* pine-apples,* bananas,* cocoanuts.* How the natives get them. How they come to us. Make a simple study of these fruits. (O, V, W.)

Make a list of plants used for food, classified as fruit, nuts, vegetables, grains, etc.; of plants that furnish us material for clothing, of trees used for lumber. (S, N, O, P.) Make a special study of flax. Have raw flax. Treat it for retting, get out the fibre, spin, weave and dye it. (S, T.)

Observe evergreens.* Review names. Note beauty, especially when grown in clumps or groves. Examine for birds-nests. Observe the birds going to bed in the evergreens. They are much used by birds for shelter. (L, 173, etc.) The story of a pine-board, simply told. The carpenter. Observe one at work. Note tools. (S, T.)

GARDENING: See work for Grade II. Window-cultures: Ferns, asparagus, umbrella plant, tulips,* hyacinths * are good for the window. Start spring cultures. Start pansy, bachelor's button, marigold, etc. Plant pieces of potato with eyes, and observe where the growth takes place. Discuss use of potato to the plant. Keep these for later transplanting. An interesting experiment in the North is raising a cotton plant from the seed. Send for good seeds. Plant early indoors and set out in garden later. (Chap. XVI, Q, 221, etc.)

SPRING

ANIMALS.

BIRDS: Early in spring begin to look for the returning birds. Make a bird calendar or book to record arrivals

by date. Later, the list should be looked over, and the early and late arrivals compared as to probable food. Also interest the boys in putting up bird boxes for wrens and bluebirds. (Chap. X, 113, 109, 478.)

Identification study: Birds learned before and song sparrow, phoebe, waxwing,* rose-breasted grosbeak.* Observe general characteristics of each bird. Use color charts. Observe outdoors the habits, song, beauty. The nesting, and the young. (H, 95, etc., 107, etc.) Do not harm, but protect. (113, 478.) Place nest materials for the birds. Set out a drinking trough. Make one at the school. (See page 143.)

In the study of the birds note more particularly adaptations of feet and bills to food and mode of life. (108, 117, 34, 33.)

How birds help the farmer, gardener, and fruit raiser—as insect eaters. (110, 108, 117, 120. See chapter IX.)

INSECTS: Observe insects in the spring flowers. (J, 200, 207.) In the garden note the cut-worms and the harm they do. What is a cut-worm? Dig up grub-worms—baby June beetles. Tell briefly of the development. Observe adults. (J, 132, 136, 126.)

MISCELLANEOUS: Informal observations of early frogs, eggs, tadpoles, toads, and aquarium studies of clam, snail, insects.

Brief study of the garter snake. Have one in a cage if possible. Teach children not to fear or harm. These snakes are not poisonous, and do good. How? Make a simple study of motions, coiling, scaly skin, shedding of skin, eyes without lids, forked tongue (harmless). Try to overcome prejudice against this harmless reptile. (I, 33, 34, 17.)

PLANTS.

GENERAL: Simple study of what the root, stem, leaves, and flowers of a plant are for. Examine typical examples of these organs. Seedlings * are good for this. Why do we water the plant? Observe delicate root-hairs on the roots of seedlings grown on a blotter under glass. These are the sucking hairs. Observe the sap. Where does it come from? Use? Do not try to teach the exact function of the leaves, but show that they are essential to the plant, by cutting off the leaves of a well-developed seedling as they appear. Note how the plant finally dies. The purpose of the flower can be observed by noting the progress * of a flower (sweet pea) to the fruit. Open fruit and find seed. Flower plan,* stamens, and pistils, parts named, and general appearance noted. (K.)

Simple experimental culture of seedlings to show that plants need water, heat, and light for growth. Make very simple, observational, informal. (K, 152, 156, 158, etc.)

Plants can move: Observe a morning-glory climb by twining.* Observe a sweet-pea tendril catching a support. Touch a sensitive plant.* (K, 154, 156.)

TREES: Review trees formerly learned. Distinguish * hard and soft maple, boxelder, birch, cottonwood (compare with willow). (173, etc.)

Shrubs: Lilac, snowball, flowering currant, berry shrubs. (185, 189.)

Observe trees in masses—the orchard,* the grove, the park, the forest.* Name all that you have learned.

Arbor Day: (See gardening below.)

FLOWERS:* Marsh marigold, buttercup, spring beauty, dog tooth, violet, rose, Jack-in-the-pulpit. Associate them with certain situations—marsh, woods, dry hills, etc.

Make a flower book or calendar, showing the spring flowers in the order of their appearance. Paint the flowers. Write simple description of each. (M, K, 168, etc.)

Gardening: Remove mulch from bulb beds. Plan garden, select vegetables and flower seeds. (See list p. 295.) Send for seed catalogues. Make sketch or plan of the garden. The older pupils should prepare the soil for this grade, but these may assist, and do the finishing. Stake out group or individual beds. Sow, plant, transplant, in season. Set out the cotton (some in pots) and the potato slips. Make a special study of the life cycle of the potato. Flax would also be a good study for this grade. (Q, Chap. XVI, 221, etc.) Make indoor experimental soil cultures with seedlings, using sand, loam, fertilizer, clay, etc., and observing which do the best. (222, 228, 196.)

Visit greenhouse and observe spring planting of the gardener. Visit a truck-garden.

Teach responsibility for the care of beds and tools. Give lessons in weeding, hoeing, watering. Study weeds in the garden. Note effects.

Set out cuttings of coleus and geranium started indoors.

Arbor Day: Make cuttings of ivy and woodbine, and set out around fences and buildings. (Chapter XVIII.) The self-clinging woodbine should be used. Plant Boston ivy and English ivy where hardy Add to the wild flower garden.

FOURTH GRADE

Aim and Method: The children of this grade having a better basis are able to study and understand more difficult matter than those of the third grade. Their imagination is

stronger and more active, their power of observation is keener and exerts more restraint upon their imagination. They can comprehend details better, and with their increased reasoning power they are able to compare, group, and generalize more successfully. But on the whole their interests are not very different from those of the preceding grade. Therefore read the suggestions at the head of the outline for Year III, page 424. The economic side of nature-study and the application of scientific principles interest this grade more.

In this grade geography begins to diverge as a formal study. Yet the close connection with nature-study requires a good deal of correlation between the two. Some phases of the geography can be more effectively taught as nature-study, earth forces for example, and the plants, animals, and mineral resources on which the great industries depend.

Suggestions for correlated art study—see page 57. The asterisk indicates subjects for drawing, painting, etc. Numbers indicate general reference list, page 521.

Throughout the Year

Earth Study: Local physiographic features. (V, 326, 327, 328, etc.) Pebbles. Why they are round. Collect in a brook * or along a lake shore.* Observe the rolling and chafing of the pebbles. Experiment with angular soft stones, and rub off the corners. (V, 326, 327, 328, etc.)

Clay: Begin in pottery to interest children in the nature and origin of clay. Visit clay bed, brickyard, pottery. (343, 324, 332, 339.) The story of the potter. (U, S, T.)

Granite: Visit ledges, or observe boulder. Note bleached appearance outside as compared with freshly broken pieces. Note the pitting on the outside. This is due to the decay or

weathering. Clay comes from these places. What are the forces of weathering? Note the variety of colors in the granite, showing its composite nature. Study mica, feldspar, quartz. Make very simple, observational. Learn to recognize typical limestone, sandstone, and shale. (343, 324, 332, 339.)

Collect and observe different soils. Keep for later cultural experiments. Visit a quarry. Note the layers of rock, springs, fissures, fossils. What are fossils? (343, 324, 332, 339.) Collect pieces of rock and fossils.

Begin a mineral collection. Put into it the rocks and minerals studied above, also metals, and ores.

Metals: Gold, silver, iron. Simple study of how they occur. The ores: Very simple explanation of extraction or reduction of ores. What are these metals used for? (343, 332, 339, 320.) Which would you rather do without? Make a list of all the things made of iron. Compare primitive man with us in respect to the use of iron. (U.)

WEATHER: Beauty of the seasons. Make a seasonal or monthly record in color of the changes in a certain bit of landscape. Make a book of it. Review atmospheric moisture studied in Grade III. Develop idea of climate. (V, W.) Make weather charts for several weeks in different seasons, recording wind direction, daily temperature, cloud forms, rain, snow, storms. Grandeur of storms. Uses of the wind, snow, ice, rain. Simpler cloud forms. (X, V, 326, 327, 328, 329.)

PHYSICS: Conduction of heat: Why are handles of teapots, stove-pokers, etc., hot? Illustrate experimentally conductors and nonconductors. Why do we have a wooden handle on a flat-iron? Why use holders of cloth for hot

things? Find more applications. Stoves, clothing, ice-boxes, ice-houses. (251, 250, 257, etc.)

ASTRONOMY: (Y, 392, 398, 329, 400.) Simpler constellations. Moon and its phases. Talks with illustrations to show the relation of sun, earth, and moon.

PHYSIOLOGY AND HYGIENE: List of staple foods. Why we cook them. (S, Z, 303, 304.) Simple talk on what happens to the food in the stomach. Hygiene of eating. (Z, 368, etc.) Freshness of meat, fruits, etc., how preserved. Clean kitchen, clean cellar. Why? (Z, 304, 209, 368, etc.)

Milk as food. Purity. (Z, 209, 368.)

Water: Sources, contamination, disease. Make very simple. (Z, 209, 368, 262.)

Temperance: Begin to develop an attitude for it. (Z, 368, etc.)

AUTUMN

ANIMALS.

MAMMALS: Observe, identify, and study the small rodents; squirrels* (red and gray), chipmunks,* gophers* (striped and pocket), muskrat, rabbit,* rats, and mice. Note habits, food, homes, colors, fur, teeth, claws, tails, and make some comparisons in structure especially of teeth—they all gnaw. The harm from these animals or their uses should be discussed. Hunting and trapping stories.* (E, 15, 33, 34, 25, 17, 61 (Story of "Raggylug"), 277, 433, 434.)

BIRDS: The birds of prey: Hawks, great horned owl,* barred owl,* screech owl, snowy owl, eagle.

Observe hawks soaring, perhaps find owls in hollow trees in vicinity. Refer to thieving of these birds. What else do they feed on? With bird charts study the sharp shinned hawk, Cooper's hawk, the marsh hawk, the red-shouldered

hawk. Compare general appearance, especially note similar beaks and claws. What are they used for? Look up the food of these hawks and form an opinion as to the harmfulness of all hawks. What good do they do? What kind of hawks should not be shot? Consider the owls in a similar way. Compare their feet and bills with those of hawks. Hawks and owls are "relatives," and show a "family likeness." (H, 95, etc. 120.)

Swimming Birds: Tame wild ducks and geese. The fall hunting season would be an appropriate time for this study. Observe the birds brought in by hunters. Observe the tame ducks and geese. Note their bills,* and feet,* their walk, how they swim and dip with their long necks. What are they dipping for? What else do they eat? Observe them in the water. Do they get their feathers wet? Why? Try a little experiment with oiled and unoiled chicken feathers in water. Preening. Moulting. Feathers used by man. The eider duck. For what other reasons do we keep ducks? Show picture of wild mallard.* Compare with the common tame duck. Domestication. Show pictures of other kinds of wild ducks, especially the teal and wood duck. Note beautiful colors. Observe the migration of ducks. Can tame ducks and geese fly? Why do they not fly away? Where do the others go? Study the swans * in the parks. Note their purity and grace. Observe how skilfully they swim. Are they graceful walkers? Why not? What is the use of such feet? Refer to wild swans. Compare all these birds as to general appearance, and especially as to feet. These also show a "family likeness." (G, H, 95, etc., 118, 120, 124.)

Game birds: Ducks, geese, bobwhite, ruffed-grouse,

prairie chicken. (H, 95, etc.) Brief study of their general appearance, where found, how hunted. Brief explanation of the reason for game laws. Show the justice in them. Begin to develop an attitude in favor of such laws and a willingness to abide by them. (113, 117, 120, 246 "Game Laws.")

Observe and identify bank-swallows. Compare with barn-swallows and martin.

INSECTS: Observe insects on flowers. Discuss in a simple way pollination and the necessity for it in producing fruit. (200, 207, 215, 156, 158, H.) Note the injury done to garden plants and tree foliage by insects. Observe especially the cabbage caterpillar. Raise some to maturity.* Note the potato beetle. Why do we put Paris-green on the plants? Grasshoppers: Observe outside and feed in cages. Read or tell about grasshopper plagues and their effects. (J, 132, 136, 148.)

Ants: Observe ant-hills. Overturn stones and boards, and observe the inside of a nest. Note numbers, some winged males and females, the whitish cocoons carried away by the workers, the minute white eggs, the passage-ways. Feed ants bits of meat, sugar, fruit. See them work. Stories of ants' industry. Collect a canful of ants, cocoons, eggs, and earth, and start an ant cage in the school. (See Chapter XIV.) Observe, feed, and water. General structure of workers.* Compare with them the small winged males, and the larger winged females, "queens." Stories of ants' intelligence, and social order. (J, 132, 133, 130, 47, 58.)

Informal observations on aquatic insects collected by pupils and kept in aquarium—wrigglers, electric-light bug,* dragon-fly larvæ, etc. (47, J.) Observe empty cases of

cicada on tree trunks. It is probably too late to see the emergence of the adult. Catch and cage cicadas.* Note wings, eyes, "snare drum" on males. (J, 47, 132, 133, 33, 34.) Note the shrill noise of the cicada on a hot day.

Bring in walking-sticks. Why so named? Where do they live? Are they easily seen? Place one on some twigs. Note how easily it escapes notice.* What advantage is it to the insect? How many legs has it? Any wings? Note feelers. Do not be afraid of it. It cannot bite or sting. Keep some in a cage and feed on fresh oak and other leaves. (J, 132, 136, 130, 54.)

MISCELLANEOUS: Collect crayfish, clams, snails, frogs, toads, turtles,* and fish, and keep them in aquaria or vivaria. Tree frogs are interesting.

Crayfish *: Note actions of living creature, swimming, crawling, pinching, feeling with antennæ. Feed bits of meat, liver, etc. Observe the jointing of the body, the hard shell, use of shell, the big pincers, the jointed legs. Under back part of body note small blades used in swimming forward. What is used in swimming backward? Where do the crayfish live? Are they easily seen? Why? If kept well long enough the crayfish may shed its shell,—a very interesting sight, and an opportunity for a lesson on that subject. (B, I, 47, 33, 34, 93.)

Simple informal observation of the actions and habits of the snail * and clam.* The pond snails are easily kept in aquaria. Get some large imported land snails, *Helix pomatia.* (33, 34, etc. 93, I.)

Observe the disappearance of frogs, toads, turtles, earthworms, gophers, etc. What becomes of them? Place a toad in a box of earth outside and observe what it does. Dis-

cuss hibernation. Refer to the bear's winter sleep. (B, 33, 34, 21, 47, 17, 24.)

PLANTS.

GARDENING: Put garden in order after the summer's neglect. Observe the effects of drought, storms, insects, and weeds. Make a collection of all the weeds found. Press and mount in a folder with simple description of what weeds are and do, and of the separate plants. Make a list of the insects found to be injurious, and the plants affected. (Weeds—230, 222, 231, 256, 246 "Weeds.") (Insects: 132, 136,148.)

Take up and exhibit with other classes at a school fair the products of the garden—flowers and vegetables. Adjudge awards. Cut bouquets for the school. Take up and pot some of the plants for winter culture. Perhaps the cotton is not quite ripe. Dig up a plant carefully and ripen indoors. Collect seeds for next year, label. Give away seeds. Exchange seeds. Set out bulbs for spring flowering. (221, 229, etc., seed catalogues.)

Prepare cuttings of currant, willow, lilac, ivy, woodbine for next spring planting. (221, 229, 232, etc.)

Mulch the strawberry bed and the bulb bed, also the cuttings and seedling trees.

Clean up for the winter.

GENERAL: The sunflower:* Begin early before all are gone. Note the great size of the flower head, its bright color, the contrast of the central part and border. Observe sunflowers growing. Note great size, broad leaves, how, in general, the heads turn toward the south or the sun, seen best in the youngest buds. Cut some of the heads off,

also some that have gone to seed. In the school-room make a study of the head. This is not a single flower, but a collection of hundreds of flowers side by side. (See page 335 and adapt.) Use black-board drawings freely, and make cuts through the head as shown in fig. 134. Observe the tubular flowers in the centre, then the rays. Derive a ray flower from a tubular flower by imagining it split open on one side. Note the "seeds," really the fruit. Examine the head gone to seed. Note how numerous the "seeds" are and how closely packed. Note the green leaf-like "scales" on the outside. Have pupils make diagrammatic drawings showing details. (Suggest saving the sunflower heads when ripe to hang out in winter for the birds.) (K, M, 154, 156, 158, etc.) Gather wild sunflowers,* asters,* daisies,* garden "single" asters,* zinnias, etc., and note that they are composites too. (168, etc.)

Annuals, biennials, and perennials: Observe in the garden how the annuals die after flowering, the same season they are sown; how beets, carrots, etc. have their leaves frozen but the roots remain alive; similarly with perennials, some are frozen above ground, others like shrubs, vines, and trees persist year after year above ground. Take up carrots,* beets,* cabbage,* etc., and save some for planting in the spring, for further study. Discuss the meaning of fleshy roots, tubers,* and bulbs* to the plant. They are storehouses of food (starch—show it) for the plant's next year's growth. What use do we make of them? Make a list of such storehouses that we eat. (K, 152, 156, 158, 154, S, R, P.)

Cereals, rice and corn included: Collect some of each. Shell or husk it. Grind some in a mortar. Observe the white powdery contents of the kernels. Examine corn-

starch and wheat-flour. What do we raise grains and corn for? What does the wheat plant or the corn plant raise the kernels for? Refer to seed wheat and seed corn. (P, R, S, 154, 156, 213, 225, 222, 228.)

Seed dispersal: Illustrations, agents of dispersal. Book illustrated with drawings, or charts. (N, K, M, 154, 156, 161.)

Simple talk on pollination—pollen transfer to stigma; no fruit otherwise. (K, 200, 156, 158.)

Visit a swamp * and observe in a general way the character of vegetation, absence of hard woods, perhaps all trees; abundance of sedges,* grasses, bullrushes, cattails,* joe-pye weed,* etc. Water-soaked soil, mud. Also visit a sand dune * or very dry soil, and note vegetation there. Compare with the other in character and abundance. Why the difference? Bring out the dependence of plants upon moisture and soil conditions. (154, 156, 158, V, 327, 338.)

Trees: Renew acquaintance with trees learned in former years. Add red oak,* basswood,* locust,* sweet gum. Make study of character of each tree. (173, etc.) Take class into a forest when trees are in autumn colors or the leaves are falling.* Observe the closeness of the trees, their slender growth, the numerous dead branches, fallen trees, decaying logs with fungi,* the matted leaf mould, the black soil underneath. Dig deeper and the soil is less black. Note birds and other animals in the forest. Observe the effect of storms. Try to identify the trees; make a list of those seen. Listen to the sighing or roaring of the wind, the creaking of limbs, the calls of the animals, and note the grace of the swaying tree tops and branches, the rustling of the leaves, the falling leaves, the shadows and lights of the forest. Notice

the landscape effects of the forest at a distance. Let children write a description of what they saw and enjoyed in the forest. (L, 220, 219, 222, 228, 216, 156, 158, 161.)

Leaf mould: Study its composition in a simple way. Plant some seedlings or geraniums in leaf mould, and in pure sand. Compare growth. Visit a greenhouse. Ask the gardener where he gets his soil for his potted plants. Why? (222, 228, 220, 219, 156, 158, 242, 229, 221.)

Flowers: Autumn composites:* Cultivated sunflower,* wild sunflower,* asters,* coneflower,* daisy.* Also identify blazing star,* toad-flax.* (M, 168, etc.)

Weeds: Visit the garden early in the fall, and note the harm done by weeds. Make a collection of these weeds, and press and hang them up in school for reference. Learn to recognize catnip, lamb's quarters, quack-grass, foxtail grass, purslane, pigweed, and study the characteristics of each. What are weeds good for? (222, 228, 140, 230; 268, etc.; 231, 256, 246 "Weeds.")

Winter

Animals.

Mammals: Carnivorous mammals—Dog,* fox,* wolf; cat,* wild cat, panther, lion,* tiger. Use pictures and observe cat and dog for types of the others. Study about the habits, homes, and food of each animal; its intelligence and powers; hunting stories and anecdotes. Visit zoölogical garden.

Study the structure of each animal, especially that of the dog and cat somewhat in detail and systematically. (See page 73 for method.) Emphasize coverings, teeth, and claws. Bring out the adaptations to food, environment,

and mode of life. Compare the animals as to these structures. Let the children consider both the canine and feline animals together, and make their own grouping of them. Ask them why they put the dog, fox, and wolf together; why they did not put the cat in with this group. Thus bring out both differences and likenesses. Do not make the grouping too scientific, but let it be rather informal. Speak of the dog's wild relations, the wild cats. (F, 34, 33, 32, 25, 17, etc.)

Birds: Interest the children in keeping poultry, doves, etc. Perhaps their parents may be induced to give them ownership rights in some of the poultry at home. Talks about what we get from poultry. How they should be cared for. Show poultry catalogue, Farmers' Bulletins: No. 41 on Fowls; 51, Standard Varieties of Fowls; 64, Ducks and Geese; 141, Poultry on the Farm; 177, Squab Raising; 200, Turkeys; 128, Eggs. (See Gen. Ref. 246.)

Also use references: 231, 222, 228, etc.

Keep children interested in the winter birds.* Have them try to attract and feed them. Read stories about them, how to be kind to them. Put out for them sunflower heads, sheaves of grain, and crumbs. Hang marrow bones and suet to the orchard trees or near the windows where the birds may be seen. (Chap. X, 109, 113, 478, 120, H.)

Plants.

Sugar: Notice sweetness of apples, etc. What makes them sweet? Where does our sugar come from? Make study of sugar-cane and the preparation of sugar. Show pictures of the plant, and the stages of preparation. (V, S, T, 256, 230, 236, geographies, magazine articles, year

books of the U. S. Department of Agriculture.) Refer to sorghum. What use do we make of it? How is the syrup made? Study the sugar beet. Get some, press out the juice, boil it down to sugar. (S, T, V, 222, 228, 231, 230, 236, 256, magazine articles, Year-books of the U. S. Department of Agriculture, bulletins from State Agricultural Schools.) Refer to maple syrup and sugar—perhaps make some when sap flows. What does the plant do with the sugar in the sap? What do we do with it?

TREES: Observe winter state, recognize those learned before. Bring in buds * and discuss their winter protection. (L, 173, 154, 156, 158, 164.)

GARDENING: Culture of potted and window-box plants. (235, 221, 229, etc.) Select plants from list page 297. Grow bulbs—tulip, daffodil, hyacinth. Lessons in potting. Later, start annuals for transplanting—list page 295. (221, 229, etc.) Distribute seeds of selected plants for competitive pot culture by the pupils at home, each child to have full responsibility for the success of the culture. Give written directions for sowing, soil, watering, etc. Exhibit condition of plants at school at the close of spring term, and if still in flower, again at the beginning of next fall. Award prize.

Make experimental cultures of window plants in sand, clay, loam, and mixtures, giving same amounts of water and same temperatures, using the same kind of plant (bean) of about the same size. Better, plant two or three plants in each kind of soil, as some may perish for unforeseen reasons. This work should teach something of the relation of the plant to the character of the soil. (Q, 222, 228, 230, 231, etc.)

Spring

Animals.

Birds: Keep a calendar or illustrated booklet of the returning birds. Observe and identify new ones. Swifts* (distinguish from swallows), the different kinds of woodpeckers,* brown thrush, wood thrush,* redwinged blackbird,* summer yellow-bird,* kingfisher, whip-poor-will. Study the main points of structure necessary for identification, peculiar habits, adaptations of feet,* bills,* etc., and the good or harm done by the birds. (H, 95, etc., 107, etc.)

Emphasize the beauty, song, the need of protection. Have children make and put up houses or boxes for wrens, bluebirds, and martins. Observe Bird Day. Read Longfellow's "Birds of Killingworth." Refer to protective laws, their purpose. Develop a desire to obey them. (Chap. X, 113, 108, 109, 117, 478.)

Make economic studies of swallows, robins, woodpeckers (different kinds), blackbird, crow, English sparrow, hawks (different kinds). Observe as far as possible the food of these birds, read about them, conclude as to their usefulness or harmfulness. Which should be protected? (120, 246 "Common Birds;" Agricultural Year-books; 95, etc., 115, H.)

Insects: Observe return of insect life. Note bees and flies in the earliest flowers. Observe them pollinating in the orchard. Suppose there were no insects here, could we raise fruit? (200, 156, 158, 154; 238, page 289.)

Observe the cutworms in the school-garden and at home. Look up remedies. (136, 132, 229.) Why is it a good thing to have the robins and toads in the garden? What are cutworms? (132, 136, etc.) (Toad: 24, 246—"The

Usefulness of the Toad.") (Birds in the Garden: 246. "Common Birds;" 120, etc.)

PLANTS.

GENERAL: Brief review of plant organs * as in Year III, Spring. Some simple experiments on absorption by roots. (222, 231, 196, 165.) Simple study of the relation of plants to light, at least the necessity of light for life. Do some simple experiments in raising seedlings * in and away from the light, other conditions being the same. Note not only the bleaching, but the spindling growth and final death. Why do we place the school-room plants in the windows? (222, 228, 154, 156, 158, 196, 165.) Note growth of seedlings toward the light,* the one-sided growth of plants not turned in window. Some flower plans.* Using wild flowers, illustrate and discuss polypetalous, tubular, and irregular flowers—these terms need not be used. The idea is to begin with a simple plan, and then to note the modifications as shown in the other types. Make comparisons and trace corresponding parts. Call attention to the beauty, symmetry, variety, color shadings, and contrasts, fragrance, etc. (152, 190, 193, 154, 158, 156.)

TREES: Poplar, choke-cherry,* hawthorn,* sumach.* (173, etc.)

Trees in blossom *—not only the fruit trees (observe beauty), but also the flowers of boxelder,* maples, cottonwood,* oaks, etc. Examine them in a general way. Learn what a catkin is. Observe abundance of pollen in boxelder and cottonwood flowers. Shake them when ripe, and note cloud of pollen. Also examine young cones and staminate clusters of conifers. (173, etc., 156, 154, etc.)

FLOWERS: Identify and study characteristic points of structure, habitat, and beauty of bellwort,* wild phlox,* vetch, puccoon,* strawberry,* shepherd's purse. (M, 168, etc.)

GARDENING AND ELEMENTARY AGRICULTURE: (Q, 221, etc.) Prepare cold-frame—simple one. Transplant the flowers started indoors, or sow others. Read up about care. (221, 229, etc.)

Plan the class garden. If plenty of ground, give each child a plot. (240, 234, 481 for plans.) (See Chapter XVI.) Make a plan on paper for the whole school, for the class and for each plot. Select the seeds to be sown. Plan where they are to go in the beds. Take into account the height of the plant and the light requirements—placing the taller on the side to the north. The boys of this grade can spade their own plots, and the girls assist in the raking and finishing. Stake out the class-garden, and the individual or group beds. If fertilizer is necessary, read up (222, 228, 231, 221, etc.) and apply as directed.

Select seeds from list, page 295. Let this class make a special study of the life-cycle of the corn plant. Note important stages, cultivate properly.

Give lessons in pricking out, transplanting, sowing, watering, weeding, etc. (221, 229, etc.) Show how to cultivate. Study weeds encountered. (See above.) Encourage home gardening. Perhaps the parents will give the children little plots of their own to work, or allow them to share the profits of the family garden.

Remove the mulch from the beds covered the previous fall. Care for the young oak, walnuts, maples, apple trees, etc., planted previous years. Perhaps they need transplanting to better and permanent places. (232, 221, 240.)

Transplant the cuttings of currants, willows, lilac, ivy or woodbine made the previous fall. Plant on Arbor Day in appropriate places. Care for them. (221, 232, 220.)

Apply the lessons on growth conditions learned in the indoor study—above.

Plant turnips, carrots, beets, cabbage, potato, and onion, and note their development the second year. What becomes of the substance of the roots, bulbs, tubers, and heads? (256, 252, 258, 254, 231.)

Exhibit the plants grown at home from the seed.

Clean up the school playground and lawn. Patch up broken fences. Remove dead vines and branches. Encourage cleaning the backyard at home, raking the front lawn, keeping it clipped, watering it, planting flowers. Arouse a pride in the beauty of the school-grounds, the boulevards and parks. Teach children to respect the efforts of people to improve their city, and not to tresspass, injure trees, etc.

Add to the wild flower garden.

FIFTH GRADE

Aim and Method: The greater maturity of the children in this grade is shown in their greater ability to reason out relations, adaptations, comparisons, and generalizations, and to make better application of their knowledge. They have a greater interest in principles, and see their bearing better. They have greater interest in inanimate nature and its forces, in inventions, and commercial values. Type studies can be used more and more, and larger group relations can be appreciated. Conditions of plant and animal life, and our own dependence on the natural environment is more apparent to them.

In general, the work is largely correlated with geography and manual training, and still largely used as the basis for other studies. Study selected types to represent large classes. Study groups to show interrelations. Classify animals and plants, to show their relationships. Do not neglect the æsthetic and altruistic side of nature-study.

Suggestions for correlated art study—see page 57. The asterisk indicates subjects for drawing, painting, etc. Numbers indicate general reference list, p. 521.

Throughout the Year

Earth-Study: Review minerals studied last year. Add to mineral collection and study metal ores, metals, salts, etc. (343, 263, etc.)

Intensive study of coal and iron. Localities, under what conditions, mining methods, reduction of iron (simple); uses of coal and iron in industries. (For coal—348, 339, 263, 320, geographies. For iron—339, 263, 320, 322, 317.)

Experiment with plaster of Paris, mortar and cement, and artificial stone to give some idea of rock formation, and also to understand something of these things themselves. (263, etc., 317, 318.)

Rock formation: Visit brook or river for sand or mud deposits. Note the stratification, the imbedded leaves, sticks, shells, footprints of birds, etc. Suppose this were to harden. Visit a quarry or rock cliff. Notice layers and finer stratification, and fossils.* Connect with experiments on artificial stone and the deposits in the brook. (327, 336, 324, 339.)

Coral:* Brief study of the polyp, especially its limy skeleton. Observe specimens of coral. (33, 34, etc.) Test with muriatic acid.

Limestone and marble: Connect with the last. Origin, nature. Test with acid. Uses of limestone. Show specimens with fossil coral. What other creatures help to make limestone? (324, 326, 327, 317, 318, 339, 343.)

Marble: Test with acid. Relation to limestone. Crystalline. Visit a marble-cutter's shop. Observe varieties of marble. Make a collection, polish. Uses of limestone—refer also to sculpture. (324, 326, 327, 318, 317, 339, 343.)

WEATHER: Rainfall record. Relation of plants to rainfall. (327, 326, 328, 158, 156, geographies.) Typical climatic regions in the United States, chiefly in the geography. (327, 328, etc.) Cause of winds (see physics below). (251, 257, 326.) Relation between the wind and the weather—simple. (327, 326, 328, etc.) Effects of frost on vegetation and animals. (Winter state of plants, hibernation, and migration of animals.) (156, 152, 158, 33, 34, 17.) Frost effects on water in air, on soil, on rocks. (327, 326, 328, etc.)

PHYSICS: Three forms of matter illustrated by experiments on water, etc. Distillation, evaporation, condensation. Experiments * and applications. Conduction of heat —experiments,* applications. Convection of air.*

Apply to heating, ventilation, land and sea winds. (These lessons must be illustrated by experiments—see Chapter V. Be sure to make the application.) (251, 250, 259, 257, 340, 449, 318.)

Inventions: Observe men at work with tools. Visit a factory, and note machinery. Visit a place where derricks, etc., are used for moving heavy weights. Compare primitive man with the present in regard to tools, machines, and other inventions. Refer to the conveniences and advantages

derived from the use of machines and tools. Study in a simple way, more for their practical use, some simple machines.* Crowbar, lever, the incline, screw (book-press), windlass, pulley. Point out the advantages gained by means of each. (For references, see the last, also 289, 288, 292.)

Discuss in a similar way, applying the principles already learned: lamps,* chimneys,* stoves,* fireplaces, kites, windmills,* sails,* water-wheels,* clocks.* Illustrate each by observation of the actual object or experiment. Note the natural agencies taken advantage of. Show how man has learned to make these inanimate forces help him, just as he has domesticated animals for his service. (References as the last.)

Metals: Identify common metals, test their useful properties. Note applications. Discuss why a particular metal and not some other is used for special purposes. Especially emphasize the use of iron.

Visit a blacksmith's shop.* (263, etc., 315, 317, 323.)

Magnet:* Experiments with attraction. Make magnets. Uses. Magnetic compass. Make one. (250, 251, 259, 318, 340, 449.)

CHEMISTRY: Experiments to show in a simple way the process of combustion. Study charcoal (carbon). Make oxygen gas. Show power to support combustion. Burn charcoal in oxygen. Show with lime-water the presence of CO_2. Observe the heat produced by the combustion. Prove the formation of CO_2 by burning a candle. Illustrate the production of heat by decay. Decay, a process of burning. Apply to hot-bed. (262, 263, 270, 272, 317, 317.) Simple experiments to show nature of acid—muriatic, vinegar, lemon; of alkali—lye, soap, soda. (274, 262, 263, 270, 272,

317, 318.) Dyes and dyeing. References as the last and 315, 316.)

ASTRONOMY: Simple study of the solar system, the earth in space, motions, shape. Use models, pictures and diagrams, geographies. (390, 402, 400, etc., and primary reference list Y.)

PHYSIOLOGY AND HYGIENE: Starchy foods, list. Effects of cold and hot water on starch. Why do we cook starchy foods? (303, 304, 274.)

Simple study of the relation, structure, and action of the digestive organs. Use charts, pictures, dissectible charts, and, better still, models. Make very simple. Show that the food is broken up fine and dissolved. What becomes of it? What is blood for? Blood is the food solution. Simple talk on the flow of the blood to all parts, feeding the muscles after they have worked. Alcohol in relation to digestion. Make simple and sane. Discuss effects of smoking. Create sentiment against alcohol and smoking. (381a, 368a, 381, 372, 379, 382.)

AUTUMN.

ANIMALS.

INSECTS: Intensive study of the bee:* A hive in charge of this class at the school would be excellent. Get an observation hive. (3, 47.) Watch bees in the field at work. See them returning to the hive. Note in the observation hive what they do with their burden. Note the honey and brood cells. Make out, if possible, the queen, drones, and workers. Tell or read about the social life of the hive. The intelligence of the bee. The work of the queen. The swarming. Hiving a swarm. Construction of hive. The life-cycle of a bee. Take out brood comb and ex-

amine the larvæ in different stages. (The same thing may be seen in the open nest of the polistes wasp.) Food plants of the bees—list. What is basswood or clover honey? Bee-keeping. The profit in it. The pleasure in it. Encourage keeping of bees. Care of bees, summer and winter. (144, 145, 129, 126, 130, 481, 133, 147, 246 "Bee-keeping.") Read about hunting wild bees—Burroughs' "Bees and Birds." Usefulness of bees in pollinating fruit trees, etc. (238 page 289, 200, 207, 215, 156.)

Compare the wasp* with the bee as to structure and habits: Note membranous wings of both, hooked together. General similarity of shape, differences. Both sting. Hold a worker wasp with pincers and observe sting thrust out. Remedy for stings. Wasp nest.* First paper-maker. Bring in nests in the fall after the cold weather has killed the wasps. Examine comb, compare with bee's. Usefulness of wasps. Compare the bumblebee * with wasp and bee. Cage some and feed on sweetened water. Observe in the clover fields. Use? Similarly compare the mud wasp * of the attics and lofts with the bee. Note interesting mud nest.* Break open and examine young larvæ. Note cells partly filled with food. What is it? Are they dead? Uses of wasps. In what respects are all these insects alike? They are called the membrane-winged group. Why? (143, 146, 145, 144, 136, 132, 126, 15, 47, 33, 34.)

House-fly:* Observe structure, number of wings, the eyes, legs, body, tongue; eating, running, cleaning wings, flying, running on the ceiling or window. Where are the flies most abundant? Leave a bone with some meat exposed in such a place. Observe the flies there. Examine the bone for eggs, and later for larvæ, "maggots." Place a rather old

cap of mushroom under a bell-glass and examine in a few days for decay. Note great number of maggots in the mass. Later, these may develop into a kind of fly. Discuss the metamorphism of the maggot. Why are flies objectionable? How do we protect ourselves? Flies as carriers of disease. How? There are many kinds of flies. (33, 34, 47, 143, 136, 148.)

Comparative study of the grasshoppers,* crickets, and green grasshoppers.* Study essentials and compare and classify. Refer to injury done by grasshoppers. Review life history. (References as the last.)

Observe plant lice, squash-bugs, potato beetle, rose beetles, tent caterpillars, and note the harm done by each. Destroy the nests of the tent caterpillar. On what kinds of trees are they chiefly found? (47, 93.) Make a collection of pond insects and other creatures for the aquarium. Protective coloration of green grasshoppers, locusts, bark colored moths. (132, 136, 129, 47, 54, 33, etc.)

SALAMANDERS AND SNAKES: Bring in spotted salamanders,* newts, garter snakes, and keep them in appropriate cages. Feed them. Observe actions and general appearance. Salamanders are not lizards. Why? They are harmless. Distinguish amphibians and reptiles. Study life history of salamander and snake. Make brief study of rattlesnake. Where is the poison? Where are these snakes found? What is the rattle for? (33, 34, 17, 35, 26.)

PLANTS.

GARDENING: Put garden in order after the summer. Observe the growth of the biennials * set out last spring. Collect seeds. Put in labelled packages. Give away and

exchange seed. Observe injurious insects and weeds. Harvest the corn * planted last spring. Use it in study of the life history of the plant. Husk the corn later. Have simple judging of the best ears (223, 239, 230, 246.)

Exhibit flowers raised in the garden. Cut for bouquets daily.*

Lessons in pruning—vines and shrubs. (229, 240, 232, 221.)

Set out bulbs for spring. Mulching for winter. (221, 229.) Take up and pot plants desired for further use indoors. Clean up for winter.

Plant wild fall perennials—sunflowers, goldenrods, asters.

GENERAL: Observe more closely the pollination by insects in flowers of the pumpkin, sweet pea, sunflower. (152, 158, 156, 216, 200, 209.)

How plants protect themselves: Observe and test the prickles on the thistle,* rose, gooseberry, raspberry; the thorns on the locust * and the hawthorn; the stinging hairs of the nettle; the sticky, bitter hulls of unripe walnuts and butternuts. What enemies might harm them? Find other examples of self-protection. (156, 152, 154, 158, 161, 193, etc.)

CEREALS: The corn plant* and the grains as flowering plants. Belated corn plants may still be found in flower early in the school year; else black-board drawings must be used to show the nature of the tassel, ear,* silk, and kernel. Note the jointed stem, the slender sheathing leaves. Uses made of the corn plant.

In a similar way treat the grains.* Study the flower of the wheat by means of drawings, supplementing as much as possible with heads. Note that each kernel has its own husk or chaff. Compare the other grains with wheat. Compare

with grasses. Note hollow stems, joints, leaves. Grains are a kind of grass. Some timothy,* wild rye,* quack-grass,* or other grass may still be found in flower. Make a general study of the flowers, noting pendulous anthers and feathery styles. Note the hollow stems, the joints, and sheathing leaves. There are very many kinds of grasses. The grains are cultivated grasses. Corn is also a grass. Refer to grass as fodder. (References on grasses and grains: 213, 230, 154, 156, 159, 152, 193, 161.)

The wheat crop: Cultivation, harvesting, threshing, milling, commerce, wheat regions. Importance to the world. Dependence of the cities upon the farmer. (225, 227, 236, 313, 316, 222, 228, 320, geographies.)

TREES: Distinguish * red, white, bur-oak, and mountain ash.* (173, etc.)

The orchard *: What kind of trees are in it? Which is the most important? Care of orchard. Picking and shipping fruit. (238, 232, 246.)

How the forest * benefits man: Make simple. Lumber, fuel, fruit, nuts, game, wind-breaks, holding back the rain-water, protecting the soil. What enemies has the forest? The lumberman, the farmer, fires, wind-storms, insects. Former extent of woods in the vicinity. What has become of them? Scarcity of wood for fuel and lumber. Necessity of preventing waste and of reforesting. Very briefly tell how forests may be planted and preserved (220, 219, 222, 227.) Distribution of forests, prairies, and plains in the United States. Character of vegetation in each. Reasons for this vegetation. Distribution of the conifers and hard-woods. Bring out relation of trees to climate, especially moisture. (Geographies, 327, 475a, 475b, 220, 219.)

FLOWERS: Review briefly sunflower as composite.* Observe wild composites like it. Study thistle * as another type of composite. (152, 156, 159, 154, 197, 193.)

Identify white and red clover * (note bees, bumblebees, and butterflies in them), prairie clover,* sweet clover (bees), monkey flower,* nettle, cocklebur.* (168, etc., 197, 200, 209, 215.)

WINTER

ANIMALS.

MAMMALS: Large game:* Hunting stories. (Appropriate in the open season). Wapiti (elk), moose deer* (white tailed). From pictures or in zoölogical gardens observe general appearance, covering, antlers, grace, fleetness, etc. Stories about habits. Food. How the antlers are shed and grow again. Examine mounted antlers. How hunted. Where found now. Why so few as compared with formerly. Game laws. Why? Read Warner's "Hunting of the Deer." Also read "The Hunt," in Scott's "Lady of the Lake," and Long's "Following the Deer." (25, 27, 17, 20, 31, 28, 61, 63, 62, 72.)

Comparative study of the ruminants: Cow * as type. General characteristics of structure: Cloven hoofs, horns, etc. The habit of chewing the cud. Why? Drawing of multiple stomach on board. Describe its use. Food of the cow. How does a cow eat grass? Examine the front part of upper jaw. Has the cow teeth there? (33, 34, 15, 18, 20.) Study (in geography) the cattle industry, the meat preservation and shipment, the leather and the shoe industries. Visit establishments to see these things. How a shoe is made. (312, etc., 320, 323, etc., geographies.) Other cud-chewers or horned animals: Study general character-

istics of structure and habits of each, habitat, food, uses, etc. The bison *—cow-like; nearly extinct; why? Where now? How hunted. Sheep * and (Angora) goat *—herds, uses. Note hoofs and cud-chewing. Brief study of the wool industry. Refer to deer and moose as belonging with the cud-chewers, and study here if not taken up before. Antelopes; treat as the others. The camel.* Why studied in this group? General appearance. Stories about its use in the desert. Ability to endure thirst and long marches. (17, 25, 27, 20, 31, 28, 63, 62, 61, 72.)

BIRDS:* Observe and attract to the homes by feeding. (113, 109, 478.)

PLANTS.

GARDENING: Competitive culture of geranium, coleus, or begonia slip at home. Start these from slips in school. When rooted well, distribute. (154, 152, 229, 221.) Care of the window plants.* Select from list, page 297. (235, 229.) Some experimental culture * with soils of different fertility. Use of manure, and commercial fertilizer illustrated. (229, 221, 235, 222.)

GENERAL: Test starch with iodine. Test potato, turnip, apple, corn, and wheat with iodine. Sources of our starch. Why the plants make the starch, and put it in these tubers, roots, and seeds. (190, 193, 152, 156, etc.)

CONIFERS:* Observe outdoors and recall names. Make a general comparative study: general conical form, horizontal branches, needles,* cones,* resin. Why called evergreens? How about the tamarack? Do the needles never fall? Look on the ground under the trees. Read about the shedding of the needles. Why called conifers? Collect

cones and needles of different kinds and compare. With the map show distribution of the conifers in the United States. Where are the white pines, spruce, balsam firs, etc. In what kind of places are the tamaracks found? What are the different kinds used for? (173, etc., 219, 220.)

Wood Study: In connection with manual training. Pine, cedar, oak, basswood, cherry, maple, butternut, hickory, birch, poplar, etc. Study the grain, color, hardness, toughness, elasticity, etc., of each kind. Visit a furniture shop and collect pieces of different sorts. In the shop trim to uniform size, sandpaper, and varnish, label and hang up in the shop or school-room. Refer to the uses made of each kind, and tell what particular quality makes it desirable for certain purposes. What kinds are used in building houses? In furniture making? In handles, wheels? For the masts of ships? For fuel? For posts, and ties, etc.? Try to identify in common articles, furniture, etc. (219, 220, 218; 173, etc.; 314.)

Spring

Animals.

Miscellaneous Mammals: What is a whale—a fish? What is a bat? Study bat,* mole,* seal, whale, as mammals. Discuss their odd habits and peculiar shapes. Show how each peculiarity is an adaptation to the mode of life, the food, or the place where the animal lives. Perhaps bats may be brought in, and moles are easily caught in traps. Observe the injury done by moles. Read about the seal "fishery." Show pictures of the herds on the Alaskan islands. Methods of killing. Wastefulness and cruelty in the killing. Efforts of the United States to protect. Something about the preparation of the sealskins. What is un-

plucked seal? Read about the whale "fishery." Where are the whales caught? What methods used? Why do we catch whales—what do we get from them? Treatment of the blubber, etc. (General: 33, 34, 15, 17, 25, 26, 20, 30.) For seals and whales see the U. S. Fish Commission reports.)

BIRDS:* Mourning dove, cuckoo, starling, yellow-headed blackbird, cowbird, chipping-sparrow. More detailed description of the habit, food, structure, coloration, adaptations, uses or injury of each than in previous grades. Observe the returning birds. On field trips note the songs and calls and try to recognize birds by these. Try to imitate. Note where birds of different kinds congregate. Assign special birds easily observed to individuals or groups of children, for special observation through the spring. Keep a record of observations, and write up in illustrated essay. Make rustic or ornamental bird houses * and put up. Let the class join in planning and making a colony house for martins, and set it up on the school or a pole in the schoolyard. Protect the birds. Do not steal the eggs. What do the game laws say about non-game birds? What do the signs in the parks say about harming birds? Birds should be allowed to live so that all may enjoy them. (113, 108, 102, 117.) Observe Bird Day. (107.)

Comparative study and classification of Scratching Birds —hen,* turkey,* Guinea fowl, peacock,* bobwhite,* ruffed-grouse, prairie hen. Brief study of the game birds in this list. Compare habits, food, feet,* scratching, bills, etc. Refer to domestication. Value. (60, 246 poultry bulletins, 99, 479, 61.) Observe and list the birds in an orchard, in a garden, in a village, in a city park, in the fields and pastures, in a swamp, on the water, (116, 118, 100, etc. See page 85.)

INSECTS: Care and observation of school beehive. (47, 133, 246 "Bee-keeping.")

PLANTS.

GENERAL: Germination studies.* The seeds,* parts, uses. Seedling,* observe in glass germinator and in soil. Note how different kinds get out of the shell.* Plant peas, beans, corn, grain, radish, flax, onion, sunflower, squash, acorn, walnut, plum or peach pit. Note what happens to the seed leaves of the bean as the seedling develops.* Cut them from a young bean seedling. Observe effect. Infer their use. Show starch in seed-leaves with iodine test. They are stores of food for the young plant. Note the delicate root hairs on the roots of the seedlings in the glass germinators.* These are the sucking hairs for drawing up the moisture and solutions from the soil. (190, 193, 201, 154, 152, 157, 222, etc.)

TREES:* Simple classification: The oaks, willows, cottonwood, poplar, hard-maple, soft-maple, boxelder, and birch. Do this by comparison of leaves,* flower,* and fruit.* Observe the flowers of these trees. Note the catkins,* and the abundant pollen that easily shakes out in clouds when ripe. Discuss wind pollination. Refer to the pollination of corn, grasses, and grains. Have children observe these later. (173, etc.; 193, 154, 156, 159, 152.)

Visit an orchard in flower.* Note the abundance of bees and other insects. What are they getting? Observe how they are dusted with pollen. Discuss how the pollen is brushed against the stigma. The importance of bees in an orchard. Why do many fruit raisers keep bees? (200, 207, 238 page 289.)

FLOWERS:* Wild-ginger, yellow vetch, honey-suckle, arbutus, water-leaf, false Solomon's seal, red clover. Meaning of color, fragrance, shapes, nectar in the flower,—devices to attract insects to bring about pollination. (200, 207, 156, 154, 158, 161.)

WEEDS: In the lawn: Plantain,* dandelion,* cheeses,* ground ivy, etc. Harm done; how? How destroy them? (168, etc.; 230, 246 "Weeds.")

PLANT GROUP STUDIES: Forest,* grass lands,* swamps,* dunes,* aquatic plants.* Visit places showing these groups. Note the conditions of moisture, and the general character of the vegetation. Show dependence upon environment. (156, 158, 190, 161.)

GARDENING AND ELEMENTARY AGRICULTURE: Methods of plant propagation *—seeds, slips, roots, tubers, bulbs, etc. Experiments with these methods. (221, 229, 222, 235.)

Make hot-bed.* Review principle. Start tomatoes, cabbages, zinnias, pansies. Teach method of potting, transplanting. (229, 221, 222, 231.)

Plan * the school-garden. (See Chapter XVI. 240, 481.) The pupils should have individual beds if possible, and several group beds for experimental planting. Plan a bed for strawberries. The pupils may spade their own plots if not ploughed for them. Let them select beforehand what they want to plant, and plan the plot so as to meet the light requirements of the plants, putting the taller to the north of the others. If fertilizer is needed let pupils apply it. Select seeds from list, page 295. If injurious insects appear, look up the methods of control. (231, 222, 229, 148, 246, bulletins, seed catalogues.)

Encourage the planting of a garden at home, or share in

the work of the family garden. If given proprietary rights at home in the produce, the children will take greater interest and pride in their cultivation.

Set out strawberries. (221, 229.)

On Arbor Day set out ornamental shrubs, seedling trees, vines, perennials. Plant cuttings of grape, ivy, etc. See list, page 298. (232, 229, 221.)

Observe Arbor Day at home by planting something permanent. Clean up the grounds at school and at home. Remove dead limbs from trees, repair fences. Develop a civic pride in school-grounds, city streets, parks, etc., and do not misuse other people's property or improvements.

Continue work with the school wild-flower garden.

Exhibit the plants raised from slips.

SIXTH GRADE

Aim and Method: The work this year is carried on much the same as that of the last. Read Aim and Method, page 452. The beauty of nature may be brought more consciously to the minds of these children. More complex relations can be worked out, as the factors of distribution, biological relations of plant groups, plants and animals in relation to each other, the conditions of plant and animal life, including human life, the application of principles of physics to inventions, and these to human life, the application of laws of chemistry in physiology, etc. While the habits of creatures are as interesting as before, the details of structure when properly connected with function or adaptation mean more and are more interesting than to lower grades. The economic aspect of nature is still more

emphasized. Simple elementary science is introduced under the head of inventions or discoveries, explanations being sought for them through experimentation. Causal relations, generalizations of principles from observations, comparisons and wider classifications can now be made. But do not make too scientific. Correlation with geography, manual-training, domestic economy, etc., should continue. In this grade it might be advisable in more rural situations to specialize the nature-study along the lines of elementary agriculture.

Suggestions for correlated art lessons—see p. 57. The asterisk indicates subjects for drawings, diagrams, painting, etc. The numbers refer to general reference list, p. 521.

Throughout the Year

Earth Study: Review briefly common minerals. Add to the mineral collection crystals of minerals and crystalline rocks of igneous origin. Make a simple study of volcanic rocks. Economic study of granite, lime-stone, sand-stone, and marble. (343, 347, 339, 336.)

Gold, silver, copper, their ores, mining, simple explanation of purification, uses. Stories of gold-miners. The silver-smith. The U. S. Mint. (336, 339, 343, 320, 262, etc., geographies, magazines.)

Soil-water: Wells and springs. Source. Conditions. Minerals in solution. "Fur" in tea-kettle. Mineral waters. Alkali soil and water. Relation to drinking and agriculture. (326, 327, 328, 262, 263, etc.; 222, 241, etc.)

Visit to boulder field, morainic deposits. Compare rocks and soil with bed rock of vicinity. Origin of these rocks and soil? Find scratched glacial pebbles.* Simple talk

about the great glacier and some of its effects. Avoid all theory. This topic should come after, and in connection with, the study of glaciers in geography. Glacial scenery—hills, lakes. (324, 332, 336, 339, 342, 344, 475.)

WEATHER STUDY: The barometer.* Keep record of pressure for several weeks. Review cause of wind.* Relation of temperature and pressure to wind. Follow the course of a storm with barometer records. Show and read weather bulletins, weather maps. Note barometer in connection with the daily bulletins. Meaning of isotherms and isobars. Observe the predictions and the verification. Follow in the papers the course of some "cyclonic" storm or cold wave. Note the course taken in North America. Note damage done to crops, shipping, etc. Read or tell about the United States Weather Bureau, its purpose, benefit to sailors, farmers, etc. Make quite simple. (326, 328, 331, 345, 329, 334, 338, 340.)

PHYSICS: Review winds (see weather, above.) Construct a barometer.* Explain the principle. Use. Keep barometer record. Perform simple experiments to show effects of atmospheric pressure. Apply to pumps.* Use models and diagrams. Observe a cistern pump for construction.* A little about the air-pump. A bicycle pump.* Compressed air—bicycle tire, pneumatic delivery in stores. (251, 250, 255, 257, etc.; 317, 318. Barometer—also 326, 327, 328, etc.)

Inventions: The balance.* Construction, equal arms. Simple talk with experiments about weight, gravity, falling bodies. Make informal and observational, rather than based on reasoning. How a lever is used. What is gained by it? What is meant by "purchase"? What is a see-

saw?* What is a balance, crowbar, pitchfork, fish-pole, etc? Do not try to apply the law of the lever, or refer to the three kinds of levers. Similarly study in a simple, experimental way simple pulley,* block and tackle, gearing, belts,* derrick.* Note particular advantages gained from each. (251, 250, 255, 257, 217, 318.)

Forces of nature man has learned to utilize: Begin with primitive man. Note absence of tools and labor-saving machines. To-day we use the forces of animals, the wind, water-power, steam, and electricity. Let children mention illustrations.* Visit places showing application of these forces. Visit a factory. What runs all the machines? (References as the last.)

Heating house by furnace—apply convection.* Hot-water heating. Apply convection. Illustrate by experiments.* (References like the last.) The kitchen hot-water tank.

City water supply:* Source. Pumping station, or reservoir, mains, water pressure (simple). (References like the last.)

CHEMISTRY: Simple experiments to make and show the properties of oxygen, nitrogen, and carbon dioxide. Show in the air, or make from the air. Combustion chemistry (very simple), oxygen of air uniting with carbon (charcoal) to make carbon dioxide. Effects of CO_2 on a flame, on life. Test in air with lime-water. Test the breath with lime-water. CO_2 in breath. Connect with physiology. (262, 263, 264, 267, 269, 270, 272.)

Natural waters: See earth study above. Ocean-water, why salt? How table-salt is made from sea water, and why it is found in the earth. (262, 263, 264, 317, 318, 326, 327, 328.)

PHYSIOLOGY AND HYGIENE: Organic impurities in well-water or other drinking water. Sources of contamination —surface drainage into well, sewage contamination in river supply. Danger of drinking such water. Diseases that may come from it—typhoid especially. (262, 263, etc., 209, 208, 381, 368, 372, 379, etc.) Simple talk about bacteria. Note putridity of peas in water after a few days. Exposed boiled potato kept moist under glass will develop a growth of bacteria. Place some peas in a bottle of water, boil for some time, and seal. Set aside and observe if decay sets in. If well done the bottle should remain clear. Briefly tell about sterilization. Refer to reason for boiling fruit for canning. Discuss filtration. How is an ordinary water filter made?* (262, 263, etc.) Simple talks on contagion, and prevention of disease. Keep hands and face clean. Clean finger nails, do not spit, do not cough in people's faces, do not put in your mouth what others have had in theirs, do not suck the pencil, do not put coins or anything but the proper things in the mouth. Turning leaves by wetting the finger is not only bad for the book, but is dangerous to the health, for others may have done the same before. Discuss the need of cleanliness in the kitchen, cellar, refrigerator, the floors of home and school, and the streets and backyards. Refer to the evils of dust. Carpets *vs.* rugs. Mopping *vs.* sweeping and "dusting." (209, 208, 274, 373, 368a, etc., 375, 387.) Why do we keep people in quarantine? Is it right? (References as last.) House ventilation*—home and school. (251, 250, 368a, etc.; 262, etc.; 386, 387.) Need for it. What happens to the air we breathe. Test breath for carbon dioxide. In a simple way discuss the source of this CO_2. Refer to the food we

eat. Char some starch or flour, to show the charcoal or carbon in it. The oxygen we breathe burns this in our bodies to make us warm, and give us energy as in an engine. Compare the body with a steam engine—very simple. Show that the food is our fuel. We eat to run the machinery of our body. The carbon dioxide is a waste, and is breathed out. Very simple study of the lungs and circulation. Use mannikin charts, diagrams, models. (379, 380, 370, 368, 368a, etc.; 267.)

Autumn

Animals.

Mammals: Distribution of animals (in geography). (18, 33, 44, geography.)

Note adaptation to climate, food, and mode of life. Arctic, temperate, tropical; animals of the forest, the plains, the sea.

Birds: Observe migration. (108, 100, 33, 34, 17, etc.) Discuss reason. What countries they go to. Use map. Show distances travelled.

Identification study:* Tern, gull, loon, snipe, sandpiper, night-hawk, kinglet, black and white creeper, brown-creeper. Note habits, food, economic value. (95 to 106; 107 to 125.)

Insects: Simple comparison and classification. Butterflies * and moths,* bee group,* dragon-flies,* beetles,* bugs,* flies* and mosquitoes, and locust * group. (33, 34, 143, 132, 130, etc.)

Codling moth. Examine a number of apples. Some will be wormy. Note the little caterpillar. Trace its life history.* Visit orchard. Try to find the moth and the cocoons. Read in the Year-books of the U. S. Depart-

ment of Agriculture about the loss to the apple crop from this insect. Remedies. (132, 136, 148, 130, 126, 222, 229, 241, etc.) Also observe the effects of scale-insects, bark and wood borers, weevils, and plant-lice. Learn to recognize these. Remedies. (References as the last.)

Discuss the advantage of birds in an orchard. Observe the birds there. (108, 100, 33, 120, 222, 241.)

MISCELLANEOUS: Simple comparative study of crayfish,* lobster,* and crab.* Study shell, casting of shell, chief organs, and their uses, locomotion, swimming, defence, food, uses, how caught, etc. (47, 84, 93, 85, 18, etc.)

From a pond or brook collect small fresh-water shrimps, minute water fleas, and observe in aquarium. They are minute relatives of the crayfish. Put some of them into a fish aquarium. Observe how eagerly the fish eat them. Refer to the importance of these little animals as food for fishes. (References as above—also 42 and 49.)

Informal observations on clams, snails, earthworm, leeches, etc. collected and kept in aquaria. Observe in the ponds, etc., also. (93, 33, 34, 47, 38.)

PLANTS.

GARDENING: Put garden in good order. Collect daily bouquets for school. Give away flowers. Collect the garden products, including flowers, and with the plants grown in the competition make an exhibit. Make awards. Collect seeds for next year. Label. Give away or exchange seeds. Let children take seeds home.

Prepare cuttings of grapes, ivy, or woodbine for the next spring for lower grades to plant. (221, 229, 226, 241, 232.)

Observe the pollination of pumpkins or squashes, and the

two forms of flowers.* Which flower produces the fruit? (152, 190, 156, etc.)

Mulch the strawberry beds. Protect other plants. Set spring bulbs (221, 229, bulb catalogues). See also page 280.

Clean up for winter.

FRUITS: Study of the structure * of some fruits: Apple, plum, peach, grape, tomato, orange, pumpkin, nut. Try to trace the apple, etc. from the flower.* Show how the different parts of the apple are formed from the flower parts. What portions are edible? Compare in different fruits. (152, 154, 156, 193, etc.)

SEED DISPERSAL: What is the meaning of sweetness, flavor, odor, and color in the fruit? Why do the plants "want" the animals to eat their fruit? Discuss dispersal of the seeds. Find illustrations in nature. Examine the vines, shrubs, and trees along a neglected fence. Note the numerous berry-bearing plants, and infer how they were started here. (152, 154, 156, 158, 161, 193, etc.) Dispersal of dry-fruits * and seeds: Poppy,* pinks, boxelder,* catalpa, thistle,* milkweed,* cocklebur,* stick-tights, burdock, balsam, and jewel weed. Refer to the agents of dispersal. (191, 198, and the references in the last.)

TREES:* Catalpa, hackberry, sycamore; white, "Norway," and Austrian pines. (173, etc., 220, 220a, 219.)

FLOWERS: Dandelion studied as a composite.* Compare with thistle and sunflower. Compare with double asters,* dahlia,* marigolds,* etc., of the garden. (152, 193, 154, 156, 159, etc.)

Identify and study Joe pye-weed,* dock,* and smartweed,* of the meadows. Also the roadside weeds: Pinnate rag-weed, tall rag-weed,* sunflower-leaved rag-weed, carpet-

weed, sandburs, squirrel-tail grass, rye grass, burdock, nettle, hemp.*

Observe zonal arrangement along the road.* Why thus distributed? Study hemp in detail. Note the abundance of the pollen of most of these weeds. Refer to wind pollination. Also to hay-fever supposed to be caused by the pollen. (168, etc.; 222, 230, 241, 156, 246 "Weeds.")

Observe the flowers in swamps, meadows, roadsides, pastures, prairies, and copses. Note characteristics and beauty * of each. (183, 184, 153, 190, 476c, etc.)

Miscellaneous Flowerless Plants: Ferns:* Note the kind of places and soil where they grow, their beauty and fragrance. Dig up some root-stalks for the school-garden and window-boxes. Press fronds of different kinds, and make an illustrated fern booklet with descriptions. Note the large root-stalk and numerous roots. Note the coiled tips of the young fronds.* On under side of leaf observe spore dots.* Shake some ripe fronds on white paper. Briefly refer to the purpose of this dust, the spores. They are not seeds, but another kind of propagative device. (193, 195, 206, 152, and for identification—179, 172, etc.)

Moss, studied in a manner similar to last. Observe the many different kinds. Note the situations they grow in. If lost in the woods how could you tell north? Note the pretty little capsules on slender stalks of many mosses. These contain spores. Examine mosses with a magnifying or reading glass. Gather some moss and put in the flower-pots and window-boxes around the flowers. Better still, make a moist chamber for them. (195, 193, 206, 152.)

Observe the beautiful lichens on the bark of trees, and on stones. Also observe the mats of liverwort on moist and

shady cliffs, or near springs. (References as the last—also 156, 159, etc.)

Mushroom:* Simple study of its form and structure, rapid growth, edibility or poisonous character. Refer to mycelium in the ground or tree as the largest part of the plant. General effect of a fungus on a tree. (195, 152, 154, 155, 159, 167, 180, 190.)

Winter

Plants.

Bacteria: (In connection with physiology). (209, 190, 152, 156.) Simple cultures of bacteria (165, 166, 209.) Show in masses, and by color, decay effects, etc., and not with microscope. Very simple experiment in contagion. (Sterilize a potato by baking. Cut with sterilized knife. Touch one-half against a dusty surface. Keep both moist under glass, and observe from day to day.) Refer briefly to disease bacteria. Sterilization experiments. Apply to drinking water.

Fruit Moulds: Simple cultures and mere observational lessons. Why is the fruit cooked in canning? (209, 165, 166, 152, 156, 158, 246 "Canning fruit.")

Plant Distribution: Visit greenhouse. Note tropical climate and observe tropical plants* such as palms, banana, amaryllis, lilies, cannas, callas, and orchids. Note the beauty and remarkable patterns in many of these flowers. Make a study of tropical vegetation and the conditions under which it grows. Take palms and orchids as typical plants. Read and show pictures. Characteristic arctic flora: Sparseness and stunting of higher plants. Sphagnum mosses of the tundras, and arctic reindeer "moss"

(lichen). Temperate flora: Region of the hardwoods, conditions required by them, principal kinds of trees. Region of the conifers—their requirements. Chief kinds. Use the map and apply geography of climates. The prairies—where, why? The grass and grain-land. Relation to rainfall. Alpine vegetation, compare with arctic. The desert plants —cactus * as type. Compare the Great Plains in North America with deserts. Cause of desert type of vegetation. Moisture the chief, temperature the next greatest factor in distribution. These lessons should be well illustrated with pictures, not merely talks reviewing the geography. (161, 156, 158, 211, 220, geographies, physical geographies, and books of travel. Perhaps use lantern slides.)

Gardening: Window gardening and greenhouse work. See list, Chapter XVI for indoor culture. (229, 235.) Give lessons * in seed sowing, transplanting, potting, repotting, layering, and cuttings. Start rose cuttings and layer carnations. (221, 235, 229, 240, 241, 224.)

Hot-bed (221, 229, 241, 222, etc.): Plant cabbage, cauliflower, tomato, egg-plant, flowers for early starting. Transplant later in garden or give to children to take home.

Animals.

Miscellaneous: The oyster: Where found, how obtained. Compare with clam.

Coral: Examine coral * skeleton of different kinds. Note beauty. Observe the pits or little holes each representing a single polyp. Very simple description of the polyp, illustrated by drawings, pictures, and, if possible, with fresh-water hydra, often in aquaria with water plants. Connect with the geography of coral islands. Do not take up the atoll theory.

Sponge: Examine different kinds. Brief description of the living animal, its sedentary habit, plant-like. How "fished" and prepared. Skeleton. The children would be interested in the little green fresh-water sponge of our lakes and streams. Perhaps a specimen may be found. (15, 18, 23, 33, 34, 88, 89, 90, 91, 92.)

Birds: A bird's wing:* Prepare wing bones and make comparison with our own arm. Bird's leg.* Treat in a similar manner. Plumage: Uses, different sorts of feathers,* moulting, spring colors. Flight. Study of a feather in detail. (108, 95, 100, 33, 34, 21, etc.)

Spring

Animals.

Birds: (95, to 125.) Cardinal,* towhee,* indigo bunting,* bank-swallow, peewee. Identify and study habits. Observe again birds learned before. Let individual children examine special birds * to write up later. Make a comparative study of the usefulness of wood-peckers (120, 110), also of hawks and owls from the economic standpoint.

Discuss and observe the mating colors of the robin,* oriole,* cardinal,* rose-breasted grosbeak,* rooster, and peacock. Refer also to the change of dress, in the fall, of the thistle bird, the bobolink, and scarlet tanager.* (95 to 125.) Talks on egg collecting, shooting, wearing feathers. Protect birds, obey bird laws, observe Bird Day. (108, 117, 113, 478.)

Insects: Observation of insects in the garden and orchard. Note harm done; look up remedies and apply. (132, 136, 148, 246, "Insecticides," "Codling Moth".)

Fishes: Identification study of the common fresh-water

fishes,* their habits, habitats, and food value. Special adaptation to food or mode of life. Primitive and modern methods of fishing,* including sea-fisheries. Connect study of fisheries with geography. Principal kinds of salt-water fish: Cod, herring, mackerel, also refer to sharks and flying fish.

Fresh-water: Bullhead, sucker, minnow, carp, salmon, (The Story of the Salmon in 468), trout, pickerel, eel, sunfish, bass, perch, stickleback. (42, 49, 46, 41, 313, 320, 322, 323.) Visit fish markets. Note methods of preservation. Keep live fish in an aquarium, and make studies upon their habits. Discuss the breathing of a fish. Examine the gills of a dead fish. Why must the water be changed if many fish are in a vessel and there are no water plants? A fish can drown in water that has been boiled and cooled. Why? (33, 34, 42.)

Read sections from the game laws pertaining to fishing. Why such laws?

Encourage obedience to these laws. Discuss the artificial hatching of fish, and the stocking of lakes and streams with them. (21, 42, magazines, and the volumes of the United States Fish Commission reports.)

PLANTS.

GENERAL: Simple lessons in plant growth,* illustrated experimentally on seedlings and plants in window-boxes or greenhouse. Review the work of the root. Show by experiment absorption from soil. Observe sap in stem. Observe maple-sap and the "bleeding" of trees and vines in spring. Show transpiration from leaves. Grow plants in dark to show relation between light and leaf-green. Do the simple iodine test on a leaf to show the presence of

starch in the green part. Use white-bordered geranium leaf. Emphasize the importance of the leaf as a starch former, the maker of the food for the plant. Without leaves the ordinary plants would starve. Do not take up here the sources of the starch, nor the relation of starch formation to light. Leave this for later year. Discuss the storage of starch for later use in roots, tubers, bulbs, and seeds. In this way we get our starch for food. Show by experimental cultures the temperature, light, moisture, and fertility conditions needed by a plant. Much of this can be appreciated by the sixth grade children, but care should be taken not to make the matter too scientific. Apply these lessons as far as possible in the school-garden. (References: 190, 152, 156, 158, 196, 165, 164, 222, 228, 241, 230, 231, 223.)

Modified leaves: Leaves change to spines—thistle * and cactus;* to cups in pitcher plants *; to tendrils partly or wholly as in sweet pea.* Observe these and refer to the advantages to the plant to have adopted these changes. (152, 154, 156, 14, 161, 193. Pitcher plants—195, 104, 192.) Bulbs * and heads * (cabbage) are also modified arrangements of leaves. They may be compared to great buds. Cut lengthwise and note structure. (See last.)

Trees: Compare walnut and butternut. Study leaf, flower, and fruit. Study comparatively the oaks.* Note that there are two forms of boxelders;* the one with staminate flowers, the other with pistillate. Refer to the method of pollination—by wind. What other trees are thus pollinated? Observe abundant pollen in such trees. Do these trees have large pretty flowers? (Refer to 152, 193, 156, 154, 159, etc.)

FLOWERS: Refer to the pollination of grasses and grains, including corn. Are their flowers large and pretty? (Same as last.)

Observe insects in roses, fruit tree blossoms, etc. Discuss their work in pollinating. Dependence of the fruit crop upon this. (238, page 289.) Compare the flowers* of apple, plum, pear, cherry, and hawthorn, and note great similarity. Family likeness. Also observe the pollination in the sweet pea. Discuss the advantage of the peculiar form in pollination. Similarly, discuss the pollination of the Jack-in-the-pulpit * and the lady's-slipper.* Discuss the meaning of color, nectar, fragrance, and peculiar form to the flower—aids in insect pollination. Compare the appearance of wind and insect pollinated flowers. Why do the latter not need pretty flowers? Make this all very simple. Illustrate with actual flowers and with drawings. (200, 193, 207, 156, 154, 158, 161, etc.)

Flowers for identification and study: Ground plum,* wild geranium,* lady's-slipper,* wild morning-glory, virgin's bower. (168, etc.)

GARDENING: See Chapter XVI. Let this grade plan * the whole school-garden as far as laying out the class plots is concerned, each grade to divide up its own. Let these children assist in spading, raking, fertilizing, etc. Lay out beds—individual preferred. Keep a few general beds for experimental work or ornamental plants. Decide upon the vegetables and flowers to plant. See page 295. Then plant or transplant when season allows. (240, 222, 224, 229, etc.)

Remove mulch from beds, etc. Cultivate regularly. Apply the principles of plant growth learned in the schoolroom. Study the weeds and injurious insects. Find reme-

dies. (Insecticides: 229, 222, 241, seed catalogues.) Urge home gardening. Encourage parents to give children ownership of their produce. Offer seedlings from school. Plant the rose cuttings and layered carnations. (221, 229, 232.) Make a fern garden in a moist shady place. Prepare a rich wood loam bed. Get the ferns from the woods. Make an ornamental rockery with trailing flowers. Arrange a birds' drinking trough at the top. If city water is available a pipe could be laid in the rock and a fountain made to play. Cement could be used to hold the rock and make plant pockets and basins for the birds.

Arbor Day: Transplant grafted trees from the school nursery in suitable places: Apple or cherry. (221, 232, 240, 229, 222, 241, 220, etc.) Follow directions carefully. Or plant perennials (list Chapter XVI), roses or other shrubs, vines or window-boxes. Observe the day at home. Encourage children to clean up the school-grounds, trim trees, etc., and have pride in their school. Encourage cleaning up and beautifying the home grounds; try to develop civic pride and a respect for the attempts of private owners to improve their places.

Elementary Agriculture: Select the best seed corn (241, 222, 228, 230.) and let the boys compete at home in the raising of corn, to be exhibited in the fall.

Soil study: Kinds suitable for corn and other crops. Soil, fertility, and soil moisture. Kinds of fertilizers. Purpose of tillage. Ploughing, etc. Methods of planting and sowing crops. Purpose of cultivation. Methods. Machinery of the farm. Adaptation of crops to soil and climate (corn, cotton). Crop rotation, purpose. (Irrigation.) Harvesting. Farm pests and remedies (insects and weeds).

Brief discussion of the principles of feeding farm animals. Their care. The farm. Importance to the nation. Independence of the farmer. Beauty of the country. Get catalogue from state or district agricultural schools and describe the work at the school. Encourage boys to attend. (228, 222, 223, 226, 227, 231, 239, 241, 242, 243, 244, 246. Yearbooks of U. S. Department of Agriculture, Reports of State Agricultural schools.)

SEVENTH GRADE

Aim and Method: The nature-study in this grade merges into what is generally known as elementary science. The difference is that the method of study is more inductive, and the pupils are made more conscious of the logic of their own thinking. The experiment is used to a greater extent and to more advantage in this grade. There is more system in the different sciences studied and they may be presented in larger units without wearying the pupil or destroying his interest. The logical requirements of the sciences receive more consideration in their presentation. All this is possible because of the greater mental maturity of the pupils of this grade.

Inanimate nature is of greater interest. Therefore we give more of earth forces, physics and chemistry, more of invention and the application of scientific principles to the industries. The economics of plants and animals receive more attention. There is more interest in the social application of the facts of science, in the welfare of the many, and in altruism toward future generations, and the outlook is more national. In these grades the scientific bent of the pupil

may be emphasized toward some special science, which may encourage him to further study in the high school.

A laboratory is a great advantage in the grammar grades. It would be well if the pupils could do considerable individual experimentation. At any rate they should be required to assist the teacher in the experiments and devise and perform many of them themselves.

In some schools it is the practice to put an elementary text-book in the hands of the pupils. This can be done with physics, physiology, and geology, and possibly with other sciences. In that case the lesson should be conducted upon the usual nature-study plan of personal observation and inference, and should not be allowed to degenerate into mere repetition of the book. Considerable reference work may be assigned in these grades, and home reading on the particular lessons or, in general, upon invention, discovery, hunting, animal stories, biography, etc., should be encouraged. The written work in nature-study may consist of recording observations in the field or the laboratory, keeping them in neat and accurate order, writing them up in home tasks and essays, or may be kept in descriptive book form. For example, the pupils should illustrate and write up in a simple way their experiments in physics.

Care should be given to the attainment of some degree of accuracy in observation, reasoning, construction, and expression. Yet do not make the mistake to apply high-school methods. The experiments should be almost wholly of the qualitative sort, and no accurate or difficult measurement should be required. Avoid teaching definitions and laws except through usage. Do not use technical language. Do none but the clearest and simplest experiments. Avoid theoriz-

ing. Make considerable of the application of principles to life situations or industries, etc., and if possible observe these applications. Allow the children to exercise their constructive and inventive talents.

The elementary agriculture becomes more and more specialized, and could be well taught in a separate department as applied science, just as we do with domestic economy and manual training.

The work in the seventh grade presents, perhaps, a greater variety of topics than the eighth, and the logical sequence of the sciences is not pressed quite so far. The reasoning demanded is also not quite so severe. Otherwise this discussion applies with equal force to both grades.

Suggestions for correlated art lessons—see p. 57. The asterisk indicates subjects for diagrams, drawings, paintings, etc. The numbers refer to general reference list, p. 521.

Throughout the Year

Earth Study: Economic geology: Building stones, clay, ores, metals (iron), mining methods; the Age of Steel; peat, coal (different kinds); salt, borax, sulphur. Discuss the chief localities where each is found, mode of occurrence, manner of getting it, treatment in purification, commerce, importance in the arts. Something may be done with the origin. (Physical geographies, and geologies, 326, 339, 330, 337, 343, 348, 475a. Geographies and commercial geographies also 320. Tarr's "Economic Geology." Industry: 316, 317, 323, 321. Inventions: 321, 287, 288, 292.)

Physics: Water power and its applications.* The steam engine,* its principle and uses. Examine an engine at work, also the boiler.* Have engineer describe the running of

the engine, its parts, etc. Use diagrams and models to illustrate general principles. Do not make complex, simply the principle of steam pressure and the action of the slide valve and piston. Uses of the steam engine. What would be some of the results without it? Visit factory, power plant, machine-shop. Examine school steam-plant. Brief study of the locomotive and a modern passenger train. The engineer. The mechanic.

Sound: Simple principles; vibration, transmission, echo, sounding-boards. Musical instruments to illustrate the principles of quality and pitch—piano, violin, flute, whistle, organ pipe, drum. The phonograph. Make a record. Thomas A. Edison. The inventor. The physics of the ear* and the voice.*

Sources of light. Rays, sunbeams in dust, mirrors* and reflection (very simple; do not try to construct image). Uses of mirrors. Where do you seem to stand? Move your right hand. Which seems to move? How is a mirror made? Study of shadows,* conditions. Experiment with a burning glass.* Show in a dark room how the rays are brought together. Very simple study of a reading lens or magnifying glass. Pin-hole camera.*

References: Physics: 251, 259, 261, 450, 255, 318, 317, 250, 257, etc.

Invention: 292, 293, 294, 285, 288, 289, etc.

Boys' books for construction and experiments: 279, 281, 283, 284.

WEATHER: Review of atmospheric physics:* Moisture, evaporation, condensation, clouds, precipitation, rain, snow, ice, frost, convection, winds. Pressure and barometer.* Relation between storms and pressure. Cyclonic storms,

cause, wind direction, general path over United States. Prediction of a progressing cyclonic storm. Follow the daily weather bulletins on map, and note the progress of the storm. Observe the wind and the barometer, and also the cloudiness, etc., before, during, and after the storm. What the weather maps tell. How predictions are made. Description of the United States Weather Bureau, its work and methods, its value to sailors, farmers, and others. Use of the thermometer, barometer, hygrometer, rain-gauge, weather maps. Keep a record of the weather with these instruments for a number of weeks in different seasons. Study the record and make out relations between the weather and the wind, pressure and temperature. (Apply in geography. Art-studies of landscapes.)

References: Physics: 251, 259, 250, 254, 257, 258, 247, 248, 449, 450.

Physical Geography and Meteorology: 327, 328, 326, 338, 334, 340, 331, 345, 341, 449. See also geographies.

CHEMISTRY: Of the kitchen: Acid (vinegar, lemon, muriatic acid). Alkali (lye, soap, soda, borax). Oil and fat. Make soap. Common salt, baking-powder, soda, and cream of tartar. Neutralizing acids or alkali. Examine and test in the laboratory the properties of each. Discuss the household use and the properties utilized. Make simple and practical. Chemistry of bread. References, Chemistries: 263, 264, 269, 266. Cooking and cleaning: 262, 268, 274.

Fuels and illuminants: Review combustion of carbon. Review oxygen. (263, 264, 269, 262.)

Iron: Smelting and reducing of iron ore. Visit smelter if near one. Simple experimental illustration (red lead on charcoal before blowpipe). Visit a foundry. Observe casting.

Visit a rolling mill, or illustrate with pictures. Discuss these processes. Visit a machine shop. (Connect with study of iron in earth-study above.)

References: Chemistry: 264, 263, 266, 270, etc. Industry and Invention: 316, 317, 318, 322, 287, 288, etc.

Physiology and Hygiene: Bacteria and disease: See experiments with bacteria in botany below. Infection. Sterilization. Disinfection. Quarantine. Sanitation of home and city. (209, 208, 199, 381a, 372, 373, 368, 375, 387.) Review rules of cleanliness given in physiology, Grade VI. Evils of dust.

Patent medicines, danger in. Value of medicines. The physician. Dr. Pasteur. Nursing rules. Emergency rules. (368a, 368, 373, 376, 371.)

The interrelations of food, circulation, respiration, and work. Make simple. Use comparison of the engine. (368a, 373, 368, 371, 372.)

General plan of the ear* and eye,* defects and remedies* and hygiene. Compare eye with a camera.* Use simple diagrams, models, etc. The voice.* Care. (368a, 368, 370, 372, 373, 380, 386.)

Astronomy: Shadows. See Physics above. Eclipses,* conditions. Phases of the moon. Observatories. Stories of astronomers. The story of the calendar. Causes of the seasons.* (390, 396, 402, 449, 391. Boyle's "Calendar Stories.")

Autumn

Animals.

Birds: List of the birds that eat grain and fruit, that eat poultry, that eat insects, that eat weed and grass seeds, that destroy field mice, gophers, etc. (120, 108, 117, 33, 34,

246 "Common Birds." Agricultural Year-books. Also see Chapter IX.) Study of the introduction and spread of the English sparrow and the results. Methods of extermination. (5, 120.)

More detailed study of migration; causes, destinations, mode of travel, routes of travel. Special study of the robin, wild duck, bobolink, humming-bird. Observe migration and feeding habits of the birds. Discussion of winter residents. (100, 108, 33, 34, 96, 64, 21 for migration.)

INSECTS: Have pupils make a collection of insects.* (See Chapter XIII.) Let the insects be neatly mounted and classified by orders. Groups might be set at work collecting and mounting sets of insects that eat vegetables, that injure shade trees, that are beneficial. Butterfly collection. Set showing protective coloration. Life history sets. A silk-moth chart. These to be kept by the school. Begin early in fall. (143, 136, 132, 33, 34, 130, 126, 148, 148a.)

General study of the food of insects. Simple study of the adaptation of the mouth organs for this food. (148, 136, 132, 231, 241, 222, 148a.)

Amount of damage done by the codling moth, by the scale insects, by chinch bugs, locusts, cotton-boll weevil. (Look up in the Year-books of the Department of Agriculture, also in magazines, in 148, 148a, 136, 130, etc.) Story of the locust plague in United States. Read descriptions from the Bible about locusts. Insecticides, how they act, how prepared and applied. (148, 231, 221, 241, 148a, 246 "Insecticides." Also seed catalogue.)

Value of bee culture. (133, 144, 246 "Beekeeping," 148a, 148.) Importance of the silk industry. (47, 312, 317, 316, 320, 246 "Silkworm," 148, 148a.)

Relation between insects and flowers, mutual benefits, our benefit. (200, 207, 215, 156, 158, 161, 238, page 289.) Relation of birds to insects (120, 108, 33, 34, 3, 246 "Common Birds," Year-books of the Department of Agriculture. See Chapter XIV.)

Parasitic Insects: Ichneumon flies, etc. Benefit to us. (148, 148a, 132, 136, 130, 33, 34.)

PLANTS.

GARDENING AND AGRICULTURE: Put garden in order after the summer's neglect.

Exhibit of corn raised in competition at home, and judging and giving award. Exhibit of vegetables and flowers, nature paintings, and drawings, note books, mounted plants, insect collections, etc. A good plan would be to exhibit at the county fair. Visit fair and observe products of the farm, garden and orchard. (Corn judging 222, 241, 228, 226, etc.)

Set out bulbs for spring flowering. Later, protect beds and plants for the winter. Clean up. (221, 229, 224, bulb catalogues.)

USEFUL PLANTS: The native fruit industry—Apple, peach grape, orange.

Study the fruit* briefly. Derive it from the flower.* Nursery work with fruit trees. Orchards, planting and care. Injurious insects and fungi. Remedies (See above—Insects; and Rusts and Blights below.) Picking and shipping. Fruit regions. Climatic conditions. Best varieties in the locality. Value of the crops. Encourage home fruit growing. Visit a commission house. (238, 232, 313, 222, 241, etc., geographies and commercial geographies, Agricultural Year-books, nursery catalogues.)

The tropical fruit industry: Banana:* Where grown, climate, the tree and fruit. Shipment and preservation. Figs and dates, similarly. (313, geographies, commercial geographies, geographical magazines, *School Science, Birds and Nature*, Year-books of the Department of Agriculture). Discuss the introduction of foreign plants into this country. Make a list including fibre plants, fruit, grains, grasses, and trees. What native plants has this country sent to other lands? (318, 317, 213, 320, "Practical Flora," by Willis.)

Aquatic Plants: Observe in river or pond. Note general character, and collect different kinds. They need not be named except, perhaps, water milfoil, pickerel weed, eel grass, duckweed, and bullrushes. Note the abundant growth. Observe the minute animals that live in it. Discuss the relation of these to fishes. Note * the gradual filling up of the pond by these weeds. Observe a swamp* and a low meadow,* and observe that these are later stages of the pond-filling process. Note the peaty substance of the swamp and meadow. Its origin? Refer to origin of coal. (156, 158, 166, 161, 153, etc.) On the sea shore, study, collect, and press seaweeds.

Trees: Observe and identify ash and Kentucky coffee tree. Make a more detailed study of leaf fall:* Manner, conditions, scars, and healing; need of leaf fall. Study the autumn colors,* both from the æsthetic and the scientific standpoint. Does the frost make the colors? Suppose the leaves are frozen, do the colors appear? Note the characteristic color changes of particular trees.* Make a list classifying the trees as to autumn colors—reds, yellow, etc. Observe that the buds for next spring are already formed. What

is their relation to the leaf scar?* (152, 156, 159, 161, 154, Flagg, "A Year with Trees," 475c.)

IDENTIFICATION: Dodder* (a parasite), poison ivy, poison nightshade, poison "jimsonweed,"* poison pokeweed, jewel weed, evening primrose,* climbing bittersweet,* gentians.* Note appearance, habitat, and characteristics. (168, etc.)

GRASSES: Stems, leaves, flowers, pollination, fruit, root-stalk, wintering, uses, native of what country: June grass, rye-grass,* timothy,* millet, the grains,* corn,* sorghum,* sugar cane, bamboo. (169, 230, 231, 222, 241, 213, 225, 152, 154, 156, 159, 161.)

WEEDS: Quackgrass,* barnyard grass,* squirrel tail grass, foxtail, sand-bur. (See last references.) Prickly lettuce, Russian "thistle," Canada thistle, mustard, mullein,* milkweed,* daisy * (whiteweed), pigweed, lambs'-quarters. These are all common field weeds. Identify them, study the harm they do, the way they spread, go to seed, how they were introduced, etc., and how they may be exterminated. Read laws against weeds. (230, 222, 241, 231, 226, 256, 246 "WEEDS.") Visit fields and observe the plants. What good can be said for weeds? What is a weed?

FUNGI: Mushroom,* shape, gills, spores, mycelium, can grow in the dark, has no green color, does not make its own food, but either steals it from a living plant (tree) or uses the food in the dead bodies of other plants. General effects of fungi, death to living plant, decay of the dead. The good done by fungi of decay in a forest. Distinction between edible * and poisonous * mushrooms. Collect as many different kinds of mushrooms as can be found. Note the variety of form, etc. Study puff-balls and shelf-fungi.* (152, 156, 190, 154, 159, 153, 220, 195, 167, 180.)

Rusts and blights: Lilac blight, etc., wheat rust, apple rust, aster rust, etc. Observations of general appearance, using a magnifying glass, general effects on the "host." Discuss the damage to wheat crop. These are plant diseases. (U. S. Agricultural Year-books, 154, 156, 153, 222, 241, 230, etc.)

Winter

Animals.

Mammals: The farm animals, general discussion of their uses, and of the various breeds suitable for one use or another. Apply especially to cattle. Study of the dairy. Best stock, care, treatment of milk, etc. The creamery and butter making. Milk tests, make some. (231, 241, 226, 228, 223, Farm Journals, Year-books of the Department of Agriculture, and Farmers' Bulletins, 246—Nos. 143, 106, 53, 241, 42, 64, 184, 34, 205.)

Plants.

Trees: The farmer's wood-lot—how to use and keep it. Farm forestry. Planting on the prairies. (220, 219, 218, 217; Farmer's Bulletin Nos. 228 and 134 in reference 246; U. S. Agricultural Year-books.)

The Life of a Tree (the Oak*): Apply the principles of absorption, soil fertility, climatic conditions, transpiration, flow of sap in stem, relation to the light, starch formation, flowering, pollination, fruit formation, seed dispersal, yearly growth of stem (annual rings *), yearly growth of twigs,* leaf fall, winter state of buds,* insect enemies, the lumberman, the farmer, forest fires, fungous parasites, storms, decay, death. (Ward's "The Oak," 152, 156, 158, 161, 220, 219, 220a, 132, 136, 148.)

GARDENING: Nursery work—grafting,* budding,* (232, 229, 230, 240, 223, 222, 241. See page 288.)

Culture of boxed and potted plants. (See Chapter XVI for list. 235, 221, 229, 224, 245.)

Talks about farmers' institutes. Attend. Call attention to the free distribution of Farmers' Bulletins (see reference 246). Send for lists.

Talks about agricultural colleges or rural industrial schools. Send for catalogue. Encourage boys and girls to attend if they have a fondness for country life.

Encourage the pupils to keep poultry, doves, etc., to take care of the cow or horse at home. Perhaps their parents may give them a calf or a colt, etc., to take care of. Let them read about how to feed, etc., and apply their knowledge. Encourage home reading of elementary books on agriculture and horticulture, seed catalogues, farm papers, etc. (See references 222, etc.) Discuss the comparative advantages of farm and city life, emphasizing the healthfulness and the beauty of the country, and the independence of the farmer. Read literature appreciative of rural life and scenes. Refer to the great men who have lived on a farm. Consider the modern improved machinery of the farm, the conveniences and even the luxuries to-day possible, such as gas, telephone, free delivery, books, and papers, rural electric lines, and consolidated schools.

BACTERIA: Connect with physiology above. Simple experimental cultures to show bacteria of decay. Experiments in inoculation of culture media; sterilization; canning fruit; bad fruit and meat. Bacteria in dust.—Hardwood floors *vs.* carpets; mopping *vs.* sweeping and "dusting." Bacteria in milk. Bacteria and disease. Contagion. Dis-

infection. Some useful bacteria: Vinegar, cheese, soil (nitrifying), tanning, etc. (209, 208, 156, 165, see also physiologies: 368a, 370, 380, 371, 386, 387, 199, 230, 242, 231.) It may be advisable to use a compound microscope to show some of the larger bacteria.

YEAST AND MOULD: Start some yeast in a dilute sugar solution. Observe. Note alcoholic odor and bubbles given off (CO_2). These substances are made by the yeast from the sugar. Set some bread. Observe rise of dough, the bubbles of gas (CO_2) formed by the yeast from the sugar in the dough. Discuss purpose of the rising. (262, 195 156, 159, 166, 263, 267, 274.) Moulds: Raise some mould on fruit or on leather. (Reference as last.)

SPRING

ANIMALS.

BIRDS:* Review of all the birds previously studied. Classify them, as swimmers, waders, and shore-birds, scratching birds, birds of prey, perching and song-birds, and miscellaneous. Make a bird calendar, note nesting, song, care of young, food, and other interesting habits. (95 to 124.)

The natural enemies of birds: Men and boys as destroyers of birds for game, eggs, "sport." Women as destroyers in wearing plumage. Tell how some of the plumage is obtained (snowy egret). Arouse sympathy for birds and a desire to protect them. Read game and bird laws. Discuss their purpose. Teach to obey them. Observe Bird Day. Read about Audubon. (403.) Form an Audubon Society. (120, 117, 100, 96, 113, 107, 122, 478, 479.)

INSECTS: Flies and mosquitoes: Briefly review with

culture experiments the life-cycles * of these insects. Note their food and how their mouths are adapted for getting it. Note the habit of flies in collecting on filthy and decaying matter. Such places are probably full of bacteria of decay, and perhaps disease. What would probably be the result if these flies should now walk on our food? Discuss further this point of flies carrying disease germs. Remedies. In a similar manner consider the mosquito that causes malaria. The mosquito biting a malarial patient may get the germs of malaria and later transmit them to others. Refer to the probable cause of yellow-fever's being a mosquito inoculating people with the fever germs. Usual remedies used against mosquitoes. Apply as far as possible at home. (129, 133, 130, 148, 33, 34, 148a.)

PLANTS.

GENERAL: The seed:* Study large seeds, such as Lima bean, squash, corn, etc., and observe the coats, and embryo or plantlet with cotyledons or seed leaves. In the corn note the germ and the food store of starch. Discuss the function of the seed-leaves. Grow seedlings * in soil and also in glass germinators (see Chapter XVII) and observe various methods of getting out of the seed and mode of growth. Note how the seedlings behave above the ground. What they do with their seed leaves.* Note especially on beans how the seed leaves shrivel. What becomes of the material that was in them? Cut off the seed leaves of several bean seedlings soon after they are above the ground and observe the starving and perishing of the plant. What is the use of the stores of starch in the corn? Dig up a corn seedling that has been growing for some time. Note that the kernel from

which it sprang is empty and soft. What has become of the material that was in it? Try this experiment: Soak some kernels of corn and cut away most of the food supply, but do not injure the germ. Plant these and observe the result. Why should we select the biggest and plumpest seeds? What part of an ear of corn would you choose for planting? Plant six fat seeds and six small seeds of corn. Observe the seedlings.* (190, 193, 152, 156, 222, 241, 228, etc.)

Movements in plants: Observe the behavior of seedlings when inverted.* (See Chapter XVII.) The stem and root move upward and downward respectively. They seem to know what to do. Observe the behavior or position of oxalis, clover, or bean that has been kept in the dark, as compared with one in the light.* Leave exposed, note movement. Observe the motion of tendrils and twining plants.* Observe the way the seedlings and other window-plants turn and grow toward the light.* Turn pot or box around and observe the motion. Touch the leaflets of a sensitive plant * and observe the closing up and shrinking away of the plant, and the motion of quite distant parts that were not touched. Can this plant feel? (190, 164, 212, 196, 165, 156, 161, 153.)

Flowers: Mayweed,* ground-ivy, purslane, cheese mallow, chickweed, an umbelliferous plant (caraway,* zizia,* carrot, parsnip,* in flower), five-finger, wood sorrel, Solomon's-seal.* Identify and study characteristics and uses or harm. (Keys: 168, etc.,—Weeds: 230, 241, 156, 246 "Weeds"; read C. D. Warner's "My Summer in a Garden," 472.) Make a collection of weeds, press, mount, and label.

Trees: Distinguish the elms, done best by flower.* Review the trees learned in previous years. What kinds are

best adapted for shade trees? Why? Which are the most rapid growers? Which are the shortest lived? Which produce a litter with their fruit? Which are most easily affected by insects and drop their leaves during the summer? Which are the most easily injured in a storm? Which tree is your favorite? Why? Draw a sketch of it and write an essay on it for Arbor Day. (173, etc., 220, 219, 220a.)

ARBOR DAY: Read up beforehand how to set out a tree. (See Chapter XVIII.) Plant a white elm, nut, or fruit tree. (220, 219, 241, 226, 221, 229.)

GARDENING: Begin early to plan garden. Select seeds and send for them. Choose from lists on page 295. Let the boys engage in a competitive cultivation of the sugar-beet, and the girls, too, if they wish, or let them choose flowers, (chrysanthemums). Read up in Farmers' Bulletins and books about the sugar-beet, and apply the directions. (Farmers' Bulletin No. 52; books: 222, 223, 241, 226, 230.) Let a committee visit the beet plots and flower beds during the summer, and in the fall exhibit the results and award prizes.

Start seeds in cold-frame or hot-bed.

Help the lower grades prepare the garden. Lay * out class garden. (Chapter XVI.) Individual plots, if possible, also a few general beds for ornamental plants or experimental cultures. Mark off, stake out, plant, etc., in season.

Plant diseases and insects: Observe. Read up, find remedies and apply. (221, 229, 241, 226, 231, 230, 246.)

Set out berry bushes, vines, shrubs, and perennial herbs for decoration or to attract the birds. Encourage pupils to do this at home.

Lessons in pruning. Give pupils the prunings to take home as cuttings for planting.

Plant outside window-boxes and care for them. List Chapter XVI.

EIGHTH GRADE

AIM AND METHOD: Read discussion at beginning of seventh grade p. 483.

THROUGHOUT THE YEAR

PHYSIOGRAPHY:* Systematic review of previous earth study, illustrated by local features as far as possible. Perhaps an elementary text-book may be used. The atmosphere, weathering, erosion, sedimentation, strata, fossils, earth waters, igneous forces, mountain formation, ores and minerals, economic resources, the coal period, coal, the ice age, sketch of the development of animal life. Use pictures, models, local illustrations. Emphasize the beauty and grandeur of the earth. Try to get pupils to appreciate the slowness of geological action. Show man's dependence upon the physiographic conditions. Apply locally and to other typical cases. Man's utilizing the forces and resources of nature. Talks on the U. S. Geological Survey. (327, 336, 328, 326, 346, 343, 348, 344, 475a, 475b, 475c, geographies, books of travel.)

PHYSICS: Common properties of matter, gravity (clocks, balancing, falling bodies, specific gravity, buoyancy). Make very simple, avoid laws and formulæ. Base upon simple experiments.

Air pressure, barometer,* pumps,* siphon,* water pressure, city waterworks,* capillarity.

Light: Review work of last year. Take up color, prism,* spectrum,* lenses,* burning glass,* magnifying glass, micro-

scope, telescope, observatories, camera,* the eye.* Use simple diagrams. Do not try to apply law of refraction or find the image with the diagrams except in the simplest manner.

Magnets,* battery,* electro magnet,* electric bell,* telegraph,* telephone, electric light,* electric motor,* electric street car.* Examine these and note construction and manner of operation. Simple explanations are hard to give. Do not go into theory. Use simple analogies, or try not to explain at all, and simply be satisfied to show the general construction and the actual operation. Emphasize rather the practical utility of these inventions.

Visit a modern newspaper printing press. Study the history of printing.

References: Physics: 251, 250, 255, 259, 317, 318, 257, 258, 260, 261, 249. Invention: 292, 286, 287, 296, 288, 289, 285, 321, 316. Boys' Books of construction and experimenting: 276, 279, 280, 281, 282, 284, 298. Biography: 405, 406, 407, 321.

CHEMISTRY:* Experimental study of elements, compounds, analysis, air, water, constituents of each, oxygen, hydrogen, nitrogen, carbon, fire, carbon dioxide, sulphur, gunpowder, matches, illuminating gas, kerosene. Properties of soda, salt, ammonia, muriatic acid, soap, lye.

Photography: Teach the process in a general way. If a dark room is available teach developing and printing. Discuss in a simple way the modern photomechanical processes —half-tone and three-color photography.

References: Chemistry: 270, 273, 263, 264, 269, 262, 268, 274, 317, 318. Inventions: See physics above.

PHYSIOLOGY AND HYGIENE: Systematic review of the

subject,* using perhaps some elementary text-book: Muscles, bones,* digestion and digestive organs,* food, cooking, blood, heart* and blood vessels, respiration* and lungs, the relation between food, respiration, and energy. Exercise, games. Ventilation.*

Bacteria and disease. Sanitation. The Board of Health.

The eye,* ear,* and other special sense organs. Nerves and brain,* their uses. Anæsthetics, surgery, antiseptics. The hospital. Nursing, invalid food, Emergency rules. Temperance, smoking. Illustrate well with observations on body, with material from the meat market, models, diagrams, pictures, experiments, and possibly the dissection of a frog. Keep to the simple. Let pupils make simple diagrams.

References: 380, 370, 381, 381a, 385, 368a, 373, 368, 371, 372, 209, 375, 387, 386, 295.

Autumn

Animals.

In connection with geography study the distribution of animals on the earth, tracing the causes that determine it. Note particular adaptations to climate, element, mode of life. Consider typical animals of different zones and also the mountains, forests, prairies, plains, deserts, and the sea. Consider the natural barriers of climate, water areas, and mountains in migration. Discuss island fauna, taking the typical animals of Australia. Very simply discuss the reason for this peculiar fauna. (33, 34, 18, 21, 22, 64, 44, Gilbert and Brigham's Physical Geography, Redway's Physical Geography, other geographies.)

Study of man: Begin with primitive man. Discuss his

dependence upon the natural environment. His enemies. His food, clothing, and shelter, and how he procured these. Discovery of weapons. Trace in a simple way through the Stone Age, the discovery of fire, of pottery, weaving, domestication of animals, the shepherd stage, cultivation of useful plants, the importance of agriculture in developing civilization, the discovery of metals, invention, utilization of the forces of nature, becoming more and more the master of the forces and resources of nature, the age of steam, the age of electricity. Consider the distribution of the races of man and modes of life to adapt to climatic conditions. Some famous migrations of races as the Greeks and Romans, the Goths, the Saracens, the Angles and Saxons to England, the Huns, etc., with some reference to the present shifting of peoples on the earth and the reasons that impel them to migrate. Bring out the dependence on nature in the case of modern civilization. (Physical geographies, histories of civilization.)

Extinct races of animals: Begin with the present destruction of animal life by man. Refer to other causes for extinction. Beaver, bison, the great auk. Fossils indicate what? Stories of animals of the past. The mammoth. Purpose of our game laws. Why is the closed season when it is? Teach obedience to the game and other protective laws. Game wardens. The American Sportsmen's League, the Audubon Society, Societies for the Prevention of Cruelty to Animals. Urge to protect animal life not harmful to us. (333, 17, 33, 34, 100, 96, 113, 478.)

PLANTS.

GARDENING: Put garden in order. Collect flowers for school-room decoration.* Exhibit flowers and produce

grown at home (sugar beets), also art and other work related to nature-study. Make awards. Exhibit at the county fair. Visit fair. Have a flower show.

Do fall pruning, give cuttings away for home growing. (221, 229, 241, 222.) Set bulbs for spring flowering. Mulch beds and protect roses, etc. Clean up for winter.

FLOWERS: Study of wild composites.* Review sunflower type, dandelion type, and thistle type. Collect, press, and make a herbarium of autumn flowers, reviewing thus the names of all learned in previous years. Note the abundance of the composites. Account for it (seed dispersal). Note the beauty * of roadside, meadow, swamp, and copses. Dig up some of the root-stalks and plant in the school wild-flower garden or in out of the way corners of the grounds, along fences, etc. Plant some at home. (190, 156, 197, 159, 161, 462, 475c; keys: 168, etc.; seed dispersal: 191, 198, 482, 161.)

FLOWERLESS PLANTS: Collect ferns,* mosses,* liverworts,* *Equisetum*,* club-mosses,* algæ (pond scum, green felt, *Pleurococcus*) and grow under suitable conditions (moisture) in the school-room. Plant fern root-stalks in the school-garden and at home, in rich soil with much decayed wood. Plant some in the window-boxes or in pots. Plant mosses around the bases of the plants in the window-boxes or pots. Put the algæ in aquaria. Observe these plants in the field. Note conditions of shade and moisture. Note growth on logs, rocks, etc. Make a simple study of ferns and mosses (see seventh grade work) and in a similar way study the other plants.

Consider chiefly the general appearance, the beauty, and the habitat, and do very little with the spores and other minute details. Spores may be shown in mass as collected

on paper. Perhaps simple experiments in growing them may be tried. Do nothing with the prothallial stages nor the alternation of generations. Examine the pond scum with a low-power compound microscope. (193, 152, 156, 159 172, 179, 475c.)

Plant diseases: Wheat rust, apple rust, sunflower leaf rust, lilac and woodbine leaf blight, potato rot, corn smut black knot, tree shelf fungi * and toadstools.* Consider chiefly from the economic standpoint. Do very little with structural details not visible with the naked eye or a simple magnifying glass. Spores may be shown in mass on paper. Consider the extent of damage done to crops and trees. Read up about remedies, especially sprays. (190, 153, 167, 180, 220, 231, 230, 221, 241, 226, etc., 246 "Fungicides.")

Winter

Plants.

Forestry: Uses of forests: Fuel, lumber, wind-breaks, game, nuts, and fruit, maple sugar, paper pulp, Christmas trees, telegraph and telephone poles, fence posts, and ties. Importance in conserving the soil moisture, retaining fertility, protecting the soil, controlling off-flow and preventing floods, and acting as reservoirs for rivers and irrigation purposes. Health resorts, scenery. Discuss the enemies of forests: Farmer, lumberman, etc., forest fires, browsing cattle and sheep, storms, drought, injurious insects, parasitic fungi. Discuss the life-cycle of a tree—youth, maturity (how old), old age and decline. The use of forests as a crop, conservative cutting, protection, replanting or allowing natural reforestation. How forests naturally reproduce themselves—coppice method, self-sowing. Show pictures or visit planted

groves—how started? Visit nursery. Refer to the planting on the prairies and changes wrought thereby. Discuss the amount of lumber still standing. Compare with former times. Trace the decline of the white pine industry in the United States. Where did it start? Where is it to-day? What shall we do when all the forests are gone? Discuss what has been done in Europe for over a hundred years in the way of forest planting and preservation, and the present condition of forests started 80 or 100 years ago. How long does it take a forest crop to become useful (thirty years), how long before mature? (80 years.) Necessity of state or national control. The work of generations. Emphasize the need of altruism in this work. Refer to the various state and national forest reserves. Use map. Relation of the national reserves to irrigation. Refer to national parks for beauty of scenery and pleasure places. An interesting case is the Sequoia Reserve in California. Study these trees. Develop a sentiment in favor of forestry. Encourage boys to turn their attention to it for practical application on the home farm or for further study for the career of forester. Describe the life and duties of a German forester. Send for Farmers' bulletins on the subject of farm forestry. Read the U. S. Agricultural Year-books on the subject, and also elementary books on agriculture and forestry. Also read magazine articles. (220, 219, 218, 217, 222, 223, 226, 228, 231, 241.) Consider the beauty of forests in scenery.* (216, 214, 475c.)

IMPROVEMENT OF PLANT VARIETIES: Discuss how the corn crop may be improved by selection of good seed. Description of Luther Burbank and his work. What he has done to change and improve plants. (210, magazines.) Make

very simple and avoid theory. (246 "Good seed corn," U. S. Agricultural Year-books.) Explain in an untechnical way how hybrids are produced, and apply to horticultural methods of getting new varieties of flowers and fruits. (156, 158, 166, 233, 161.)

Experimental cultivation of plants at state and U. S. Experiment Stations to get better producing varieties, more drought or cold resistant kinds. Experiments in adapting crops to special soils, climates, etc. Refer to apple tests (what kinds are the best adapted locally—why?), macaroni wheat, and alfalfa. Why is each variety specially suitable for the region? (U. S. Agricultural Year-books, State Agricultural Reports, Reports of Farmers' Institutes, 233.) Discuss with the map the chief agricultural or crop regions in the United States and consider the special climatic, soil, or other features to be taken into account. (Geographies, commercial geographies, physical geographies, U. S. Agricultural Year-books. 246 "The Apple and how to Grow it."

Introduction of foreign plants in suitable regions: Orange, lemon, figs, dates, Siberian apples, Russian semi-arid wheat, Indian millets, Japanese flowers, Australian eucalyptus trees, etc. Most of our fruits, vegetables, flowers, and grains have been introduced. What are our native useful plants? U. S. Agricultural Year-books; 238; Willis's "Practical Flora"; 213. Commercial geographies.)

Gardening: Greenhouse work. (See Chapter XVI.) Layering, cutting, grafting, budding (roses, nursery stock). Cross-pollination by hand. Forcing flowers and vegetables. Seed purity tests. (221, 229, 241, 222, 226, 232.) Indoor window culture in school-room. (See list, Chapter XVI. 235, 221, 229.)

Home reading of agricultural books, seed and nursery catalogues, planning home garden. Send for catalogues of state or county agricultural schools. Put them into the hands of boys and girls. Discussion of the aims and work of the U. S. Department of Agriculture.

ANIMALS.

BREEDING chickens and doves by selection. Discuss general principles. Apply same in a general way to stock, horses, etc., to show how great improvement can be made in farm animals for special purposes. Apply to selection of dairy stock and beef. (33, 34, 222, 223, 226, 241. U. S. Agricultural Year-books.)

SPRING

BIRDS:* General review of the facts of bird life previously learned. Structure and adaptation of body, plumage, wings,* feet,* bills.* Protective and mating colors. Listing of useful and harmful birds. Discussion of the food of birds. Identification of all birds previously learned, and the vireos, summer yellowbird, Maryland yellowthroat, black and white creeper, and redstart. Characteristics of warblers as a class. Classify all the birds learned into orders: Swimmers and Divers, Shore birds and Waders, Scratching Birds, Birds of Prey, Song and Perching Birds (and these again into Families). Visit a museum and observe the relationships as shown by the arrangement of the specimens. Visit a zoölogical garden. (95 to 125. Also 33, 34, 36, 47, 54.)

Encourage children to read bird magazines. Give books to take home. Encourage interest in bird study, but check

unnecessary or unpromising egg-collecting and shooting. Read from Audubon, Burroughs, Torrey, Miller, etc. Develop love and protection for birds. Encourage formation of Audubon society. Discuss the work done by this society. Discourage the use of plumage. Show the girls the cruelty of it. How we may attract the birds to our homes. (Chap. X, 479, 478, 113, 117, 108, 109.)

PLANTS.

FLOWERS: Review of the plants * learned in previous grades. Collect, press, and mount in herbarium. Do not waste flowers. Dig up wild flowers and place them in school or home garden. Note peculiar habitats, adaptations, type of flower, and peculiar adaptations of the flowers, fruit and seed dispersal, economic value. (168 to 187, 190 to 215.)

Make a comparative study * of the following families, noting similarity in flower, fruit, etc.—a family likeness:

Crowfoot Family: Marsh marigold, buttercup, hepatica, windflower, columbine.

Mustard Family: Shepherd's-purse, sweet alyssum, candytuft, horseradish, radish, cabbage, turnip, field mustard.

Violet Family: Blue, yellow, and white violets, cultivated violet, pansy.

Pea Family: Sweet pea, garden pea, bean, vetch, groundplum, red clover, white clover, alfalfa, melilot, prairie clover, wistaria, locust, peanut, sensitive plant.

Rose Family: Wild and cultivated, plum, cherry, peach, spirea, fivefinger, strawberry, raspberry, blackberry, hawthorne, pear, apple, mountain ash.

Gourd Family: Cucumber, squash, pumpkin, watermelon, musk melon, gourds.

Parsley Family: Parsnip, caraway, celery, carrot, wild carrot, zizia.*

Composite Family: Sunflower, dandelion, thistle, cultivated and wild asters, goldenrod, daisy, fleabane, marguerite, eupatory, blazing star, fireweed, lettuce, prickly lettuce, everlasting, ragweed, cocklebur, burdock, zinnia, coneflower, golden glow, marigold, bur marigold, dahlia, coreopsis, cosmos, mayweed, tansy, bachelor's button, etc.

Do not go into details further than to be able to see the similarities and the family likenesses. Do not emphasize the classification nor make it technical. Do not try to define the family characteristics. Let the work be largely observational, and let the plants be placed side by side in groups, so that the children may see the relationships. Let the children arrange their herbaria according to this classification. (152 to 166, 191, 193, 197, 200, 215.)

GARDENING AND AGRICULTURE: Nursery work, pruning vines, shrubs, trees, setting out trees, shrubs or perennials, water gardening. (221, 229, 222, 226, 241, etc.)

Preparing and applying fertilizers, sprays for insects and fungi. Encourage home gardening, tree planting, berry shrub planting, etc. Give from surplus of plants raised in school garden. (221, 229, 226, 241, etc.)

Encourage ownership and care of garden at home, of poultry, squabs, sheep, calves, cows, colts, etc. Apply the principles learned at school.

Arbor Day: Set out hard maple—or some other tree, shrub, vine, or perennial. (220, 219, 221, 229, 241, 226.)

Teach the elements of landscape gardening. (221, 229, 224, 222, 226, etc.)

Develop interest in school-ground improvement, home and

civic improvement. Make a study of the beautification plans of the city.

This class can be employed in making seats, rustic gates and fences, arbors, arches, urns, etc., for the garden. The general supervision and preservation of the order and beauty of the grounds may be left to them. (246, 221, 229, 224, 222.)

APPENDIX

Primary Information Books and Nature Stories

More or less adapted, and more or less true. For grades from the Kindergarten to the Fourth inclusive. Arranged by topics.

A. Books that Contain Something on Almost Every Nature Topic:

1. The Child's World: Poulson.
2. The Story Hour: Wiggin and Smith.
3. Five Minute Stories: Richards.
4. The Plan Book: George.
5. Month by Month: Willis and Farmer.
6. Mother Nature's Children: Gould.
7. Friends and Helpers: Eddy.
8. All the Year Round: Strong.
9. Through the Year: Clyde and Wallace.
10. The Outdoor World: Furneaux.
11. Cat Tails and Other Tales: Howliston.
12. Story of Woods and Fields: Brown.
13. Outdoorland: Chambers.
14. Orchardland: Chambers.
15. Land and Water Friends: Bamford.
16. Lookabout Club: Bamford.
17. Talks about Queer People: Bamford.

B. Animals in General:

1. Four Feet, Two Feet, and No Feet: Richards.
2. Claws and Hoofs: Johonnot.
3. Feathers, Fur, and Fins: Cheney.
4. Little Friends in Feathers and Fur: Miller.

5. Funny Friends: Miller.
6. About Animals: Carter.
7. Familiar Animals: Monteith.
8. Some Useful Animals: Monteith.
9. Living Creatures: Monteith.
10. Short Stories about Shy Neighbors: Kelly.
11. Animal Ways and Claims: Carrington.
12. Aunt Louisa's Book of Animal Stories: Valentine.
13. Little Beasts: Cram.
14. Sea (Animal) Stories: Hardy.
15. Beasts and Birds: Wright.
16. Story of Little Fishes: Müller.
17. Story of Little Animals. (Phyllis Books): Mulets.
18. Mother Nature's Children: Gould.
19. Natural History: Miles.
20. Book of Natural History. Young Folks' Library.
21. Book of Animal Stories. Young Folks' Library.

C. Cats and Dogs and other Pets:

1. List A, Nos. 1 to 7.
2. Petland: Wood.
3. Petland Revisited: Wood.
4. Cat Stories (from *St. Nicholas*): Carter.
5. Friends and Helpers: Eddy.
6. Cats and Dogs: Johonnot.
7. Letters from a Cat: H. H. Jackson.
8. Crib and Fly. (Two dogs): Dale.
9. Sofat and Mewmew. (Cat and dog): Craik.
10. Familiar Animals: Monteith.
11. Our Home Pets: Miller.
12. Beautiful Joe: Saunders.
13. Duke: Flanagan.
14. *St. Nicholas.*
15. See also List B, 1, 6, 21, etc.

D. Horse, Cow, Sheep, etc.

1. List A, 1 to 7.
2. Life on a Farm: Bradish.
3. Familiar Animals: Monteith.
4. Useful Animals: Monteith.
5. Horse and Other Animal Stories: Cassells.
6. Black Beauty: Sewell.
7. List B, 1, 6, 11, 2, 21, etc.

E. Small Wild Animals:

1. Story of Little Animals. (Phyllis Books): Mulets.
2. Little Folks in Feathers and Fur: Miller.
3. Beasts and Birds: Wright.
4. Friends and Helpers: Eddy.
5. Short Stories of Shy Neighbors: Kelly.
6. Little Beasts: Cram.
7. Familiar Animals: Monteith.
8. Four Feet, Two Feet, and No Feet: Richards.
9. Funny Friends: Miller.
10. Animal Stories: Carter.
11. Talks about Animals. (From *Youth's Companion.*)
12. Squirrels and other Furbearers: Burroughs.
13. See also List A, 1 to 7, etc. Also List B, 3, 11, 12, 18, 19, 20, 21.
14. Animal Pictures from Life. Rand, McNally.
15. *Birds and Nature.*
16. Animal Chart: Mumford.
17. For pictures, see General Reference List, Natural Histories.
18. *St. Nicholas.*

F. Large Wild Mammals:

1. Claws and Hoofs: Johonnot.
2. Familiar Animals: Monteith.
3. Four-Footed Americans: Wright.
4. Funny Friends: Miller.
5. Animal Life: Cooper.
6. Natural History: Miles.
7. Book of Natural History. Young Folks' Library.
8. Animal Story Book. Young Folks' Library.
9. Ways of the Wood Folk: Long.
10. Four Feet, Two Feet, and No Feet: Richards.
11. About Animals: Carter.
12. List A, 1 to 7.
13. List E, 14, 16, 17, 18.

G. Poultry:

1. Feathers and Fur: Johonnot.
2. Friends and Helpers: Eddy.
3. Four Feet, Two Feet, and No Feet: Richards.
4. Feathers, Fur, and Fins: Cheney.
5. Animal Stories (from *St. Nicholas*): Carter.
6. See List Q, Farm Life.
7. See List A, 1 to 7. List B, 19–21.

8. *St. Nicholas.*
9. *Birds and Nature.*
10. Farmers' Bulletins, General Reference List, No. 246.

H. Wild Birds:

1. Story of Birds. (Phyllis Books): Mulets.
2. Birds and Beasts: Wright.
3. Little Folks in Feathers and Fur: Miller.
4. Four Feet, Two Feet, and No Feet: Richards.
5. First Book of Birds: Miller.
6. Second Book of Birds: Miller.
7. Funny Friends: Miller.
8. Birds through an Opera Glass: Merriam.
9. Birdworld: Stickney.
10. Birdlife: Weed.
11. History of the Robins: Trimmer.
12. See List A, 1 to 7. List B, 19, 20, 21.
13. See General Reference List—Birds.
14. *Birds and Nature, Bird-Lore, St. Nicholas.*
15. Bird Pictures for Identification:
    Bird Chart (Colored): Mumford.
    Audubon Bird Chart (Prang Educational Co.).
    Bird-Lore Bird Chart.
    Bird Neighbors. (Colors): Blanchan.
    Birds that Hunt and are Hunted. (Colors): Blanchan
    Colored Pictures of Birds: Mumford.

I. Frogs, Toads, Fish, etc.:

1. See List A, 1 to 6.
2. Friends and Helpers: Eddy.
3. Living Creatures: Monteith.
4. Mother Nature's Children: Gould.
5. Story of the Little Fishes: Müller.
6. Animal Life: Cooper.
7. Natural History: Miles.
8. Book of Natural History. Young Folks Library.
9. List A, 10, 11, 15, 13. Also List B, 5, 11, 14.
10. *St. Nicholas.*

J. Insects, Spiders:

1. Wings and Stings: Doulton.
2. Butterflies and Bees: Morley.

3. Insect Folk: Morley.
4. The Bee People: Morley.
5. Wasps and their Ways: Morley.
6. Mother Nature's Children: Gould.
7. Buzbuz: Pratt.
8. Neighbors with Wings and Fins: Johonnot.
9. Insect Story. (Phyllis Books): Mulets.
10. Buz: Nöel.
11. List A, 1 to 7, 10, 13, 15, 16. List B, 9, 11, 19–21.
12. For Identification, etc., see General Reference List—Insects.

K. Plants in General:

1. Plants and their Children: Dana.
2. Botany All the Year Round: Andrews.
3. First Studies in Botany: Atkinson.
4. Short Stories in Botany for Young Children: Cooper.
5. Outlines in Botany—I and II: Newell.
6. Readers in Science: Murche.
7. Flowers and their Friends: Morley.
8. Seed Dispersal: Beal.
9. Seed Babies: Morley.
10. Little Wanderers: Morley.
11. Mother Nature's Children: Gould.
12. See List A, 1 to 6.
13. *Birds and Nature, St. Nicholas.*

L. Trees, Leaves, Buds:

1. Tree Story. (Phyllis Books): Mulets.
2. Tree Stories: Müller.
3. Ten Common Trees: Stokes.
4. Through the Year: Clyde and Wallace.
5. All the Year Round: Strong.
6. List K, 1 to 6.
7. For Identification, etc., see General Reference List—Trees.
8. List A, 1 to 6.
9. Trees in Prose and Poetry: Stone and Pickett.

M. Wild Flowers:

1. Flower Story. (Phyllis Books): Mulets.
2. Flowers and their Friends: Morley.
3. Plants and their Children: Dana.
4. Botany All the Year Round: Andrews.

5. Outlines in Botany, II: Newell.
6. For Identification, etc., see General Reference List—Plants, 168, etc.
7. See List A, 1 to 6, etc.

N. Fruit, Nuts, Seed Dispersal:

1. Plants and their Children: Dana.
2. Seed Babies: Morley.
3. Outlines of Botany, I and II: Newell.
4. Botany All the Year Round: Andrews.
5. First Studies in Botany: Atkinson.
6. Botany: Bergen.
7. Little Wanderers. (Seeds): Morley.
8. Seed Dispersal: Beal.
9. Mother Nature's Children: Gould.
10. Through the Year: Clyde and Wallace.
11. All the Year Round: Strong.
12. Foods and their Uses: F. O. Carpenter.
13. How We are Fed: Chamberlain.
14. *St. Nicholas* and *Birds and Nature.*
15. See List A, 1 to 7, 14. List K, 4, 6.
16. General Reference List, 154, 155, 160, 161, 213, 238 are useful.

O. Tropical Fruits, etc.:

1. Under Sunny Skies: Ginn.
2. From Lands of Sunshine: Riggs.
3. Children of the Palm Lands: Allen.
4. See others of List T.
5. *Birds and Nature.*
6. Information Readers: Clifford.
7. Elementary Geographies: Dodge, Fairbanks, Frye, King, Tarr and McMurry.
8. Geographical and Popular Magazines.
9. See List A, 1 to 5.

P. Vegetables and Farm Products (Grain, Corn, etc.):

1. Seed Catalogues.
2. See Lists R and S.
3. See Elementary Geographies—List O, 7.
4. List N, 12 and 13.
5. List K, 1, 2, 4, 6.
6. List A, 1 to 5.

Q. Gardening, Outdoors and Indoors:

1. Many suggestions in pedagogical journals, especially in *Nature-Study Review; Elementary School Teacher, Teachers College Record.*
2. Also many suggestions in Farm Journals, *Women's Home Companion, Ladies' Home Journal, Country Life, St. Nicholas.*
3. Seed Catalogues of Vick, Maule, etc., have practical suggestions.
4. Mary's Garden and How it Grew: Duncan.
5. Outline for School Garden. (Hyannis Normal School): Brown.
6. Miniature and Window Gardening: Allen and Godfrey.
7. How to Make a School Garden: Hemenway.
8. The Practical Garden Book: Bailey and Hunn.
9. Garden Making: Bailey.
10. Little Gardens: Skinner.
11. See other books on the General Reference List—Agricultural and Gardening.
12. What Shall We Do Now? Page 259: Lucas.
13. See Agricultural Bulletins, General Reference List, No 246.

R. Farm Life and Farm Industry:

1. Story of Country Life: Bradish.
2. On the Farm: Parker and Helm.
3. Playtime and Seedtime: Parker and Helm.
4. Harold's Rambles: Troeger.
5. A Boy on a Farm: Abbott.
6. Alice and Tom: Brown.
7. Sandman's Farm Stories, 2 vols.: Hopkins.
8. List A, 1 to 5, 13.
9. Through the Farmyard Gate: Poulson.
10. Life on the Farm: Shepard.
11. Elementary Agriculture: Hatch and Hazlewood.
12. First Principles of Agriculture: Goff and Mayne.

S. Food, Clothing and Shelter, Fire:

1. Industrial Readers: F. O. Carpenter.
2. How We are Fed: Chamberlain.
3. How We are Clothed: Chamberlain.
4. How We are Sheltered: Chamberlain.
5. Information Readers: Clifford.
6. Industries of To-Day: Chase and Clow.
7. Science Readers: Murche.
8. Story of the Land of Sunshine: Riggs.
9. Industries of To-Day: Lane.

10. Some Useful Animals: Monteith.
11. Tree Men, Cave Men (2 vols.), Tent Dwellers: Dopp.
12. List A, 1 to 5.

T. Occupations and Industries:

1. Industrial Readers: F. O. Carpenter.
2. Stories of Industry: Chase and Clow.
3. Great American Industries: Flanagan.
4. Information Readers: Clifford.
5. How We are Fed, Clothed, and Sheltered (3 vols.): Chamberlain.
6. Readers in Science: Murche.
7. Geography of Commerce and Industry: Rocheleau.
8. Elementary Geographies: Dodge, Frye, King, Tarr and McMurry.
9. See List A, 1 to 5.
10. Industrial-Social Education: Baldwin.

U. Primitive Life. Indians:

1. The Tree Dwellers: Dopp.
2. The Cave Dwellers (2 vols.): Dopp.
3. The Tent Dwellers: Dopp.
4. Ten Little Boys on the Road of Long Ago: Andrews.
5. Indian Child-life: Deming.
6. Red Folk and White Folk: Deming.
7. Hiawatha (prose) Primer: Holbrook.
8. In Field and Pasture: Dutton.
9. Hunting and Fishing: Dutton.
10. The Story of Ab. (Adapted): Waterloo.
11. Robinson Crusoe. (Adapted): De Foe.
12. Seven Little Sisters: Andrews.

V. Home Geography and Earth Study:

1. Home Geography for Primary Grades: Fairbanks.
2. Home Geography: Dutton.
3. Story of Our Mother Earth: Fairbanks.
4. Home Geography: Troeger.
5. Longmans' Pictorial Geography Reader.
6. Brooks and Brook Basins: Frye.
7. Elementary Geography: Dodge.
8. Elementary Geography: King.
9. Elementary Geography: Tarr and McMurry.
10. Wonders of the Earth, Sea, and Sky. Young Folks' Library.
11. Geography of Commerce and Industry: Rocheleau.

W. People in Other Lands:

1. Seven Little Sisters: Andrews.
2. Ten Boys of Long Ago: Andrews.
3. People of Other Lands: Shaw.
4. The World and Its People: Dunton.
5. Around the World: Carroll.
6. Little Folks in Many Lands: Chase.
7. Five Little Strangers: Schwartz.
8. Children of the World. Educational Pub. Co.
9. Little People of the Sun: Müller.
10. Under Sunny Skies: Ginn.
11. Stories from the Land of Sunshine: Riggs.
12. Children of the Palm Lands: Allen.
13. Eskimo Stories: Smith.
14. The Snow Baby: Peary.
15. *St. Nicholas, Youth's Companion.*

X. Weather, Wind, Rain, Snow, Ice, Frost, Months and Seasons:

1. Nature Study: Mrs. Wilson.
2. See List V, Home Geography.
3. Mother Nature's Children: Gould.
4. Science Readers: Murche.
5. Calendar Stories: Boyle.
6. Book of Nature Myths: Holbrook.
7. Nature Myths: Cooke.
8. List A, 1 to 5, 11.
9. For poems—Posy Ring and Golden Numbers: Wiggin and Smith. Also Beeson's Child's Calendar Beautiful.

Y. Sky, Stars, Sun, Moon:

1. Stories of Starland: Proctor.
2. Nature Study: Mrs. Wilson.
3. Storyland of Stars: Pratt.
4. Easy Star Lessons: Proctor.
5. Overhead: Nichols.
6. Wonders of Earth, Sea, and Sky. Young Folks' Library.
7. Nature Myths: Cooke.
8. Stars in Story and Legend: Porter.
9. Book of Nature Myths: Holbrook.
10. See List A, 1 to 5.
11. For Poems: List X, 9.

Z. Health, Physiology:

1. Good Health: Jewett.
2. Town and City: Jewett.
3. Child's Book of Health: Blaisdell.
4. How to Keep Well: Blaisdell.
5. How to Teach Physiology: Blaisdell.
6. Primary and Intermediate Physiologies: Overton.
7. Primary Physiology: Baldwin.
8. See General Reference List, 368, etc.

General Reference List

P indicates books adapted for primary grades, or useful for the teacher; I, for intermediate; G, for grammar.

Nature Study Methods

1. Arnold's Waymarks for Teachers. Silver, Burdette & Co.
2. Bailey: The Nature Study Idea. Doubleday, Page & Co.
3. Hodge: Nature Study and Life. Ginn & Co.
4. Jackman: Nature Study. H. Holt & Co.
5. Jackman: Nature Study for Grammar Grades. Macmillan Co.
6. Lange: Nature Study Handbook. Macmillan Co.
7. Ricks: Object Lessons. D. C. Heath & Co.
8. Salmon: Object Lessons. Longmans, Green & Co.
9. Scott: Nature Study. D. C. Heath & Co.
10. Wilson: Nature Study for Elementary Schools. Macmillan Co.
11. McMurry: Special Methods in Elementary Science. Macmillan Co.
12. Baldwin: Industrial-Social Education. Milton Bradley Co.
13. Lloyd and Bigelow: Teaching of Biology. Longmans, Green & Co.
14. Jackman: Field Work in Nature Study. Flanagan.

Zoölogy

Text-Books, Natural Histories, and Identification Books:

15. G Colton: Zoölogy. D. C. Heath & Co.
16. Hertwig-Kingsley: Manual of Zoölogy. H. Holt & Co.
17. I, G Hornaday: Natural History. Scribners.
18. G Jordan, Heath and Kellogg: Animals. Appletons.
19. Jordan: Manual of the Vertebrates. (Key.) McClurg & Co.
20. G Riverside Natural History. Houghton, Mifflin & Co.
21. I, G Kellogg: Elementary Zoölogy. H. Holt & Co.
22. G Thomson: Outlines of Zoölogy. Appletons.

23. I, G Wood: Natural History.
24. G Marshall: The Frog Book. Doubleday, Page & Co.
25. I, G Ingersoll: The Life of Animals. Macmillan Co.
26. I, G Boys' Book of Natural History. Young Folks' Library. Hall & Locke.
27. I, G Animal Stories. Young Folks' Library. Hall & Locke.
28. I, G The People's Natural History. University Society.
29. All Miles: Natural History. Dodd, Mead & Co.
30. I, G Sherren: Popular History of Animals. Lippincott.
31. I, G Wright: Four-Footed Americans. Macmillan Co.
32. I, G Harvey: Introduction to Zoölogy. American Book Co.
33. I, G Linville and Kelly: Zoölogy. Ginn & Co.
34. I, G Davenport: Zoölogy. Macmillan Co.

General Zoölogy

35. I, G Baskett: Reptiles and Amphibians. Appletons.
36. G Buckley: Winners of Life's Race. Appletons.
37. I, G Burroughs: Squirrels and Other Furbearers. Houghton, Mifflin & Co.
38. G Cooper: Animal Forms. American Book Co.
39. I Conn: Method of Evolution. Putnams.
40. G Flower: The Horse. Appletons.
41. G Goode: American Fishes. Estes & Lauriat.
42. P, I Baskett: Story of the Fishes. Appletons.
43. G Heilprin: Distribution of Animal Life. Appletons.
44. G Hornaday: Taxidermy and Zoölogical Collecting. Scribners.
45. G Jordan and Evermann: American Food and Game Fishes. Doubleday, Page & Co.
46. I, G Kellogg: First Lessons in Zoölogy. H. Holt & Co.
47. G Lane: All about Dogs. J. Lane.
48. G Baskett: Story of the Fishes. Appletons.
49. I, G McCarthy: Familiar Fishes. Appletons.
50. Metcalf: Outline of Organic Evolution. Macmillan Co.
51. P, I Monteith: Familiar Animals and their Wild Kindred. American Book Co.
52. P, I Monteith: Some Useful Animals. American Book Co.
53. Morris: Man and His Ancestors. Macmillan Co.
54. Poulton: Colors of Animals. Appleton.
55. I, G Porter: Wild Beasts. Scribners.
56. G Roosevelt, Van Dyke, etc., The Deer Family.
57. I, G Rice: Animals. Stone & Co.
58. Romanes: Animal Intelligence. Paul, Trench, Truebner & Co.

59. All Burkett: Our Domestic Animals. Ginn & Co.
60. G Shaler: Domesticated Animals. Scribners.
61. All Seton: Wild Animals I Have Known. Scribners.
62. I, G Seton: Lives of the Hunted. Scribners.
63. All Stone and Cram: American Animals. Doubleday, Page & Co.
64. Thomson: Animal Life. Scribners.
65. Seton: Animal Heroes. Scribners.
66. All Cram: Little Beasts. Small, Maynard.
67. I, G Long: Ways of the Woodfolk. Ginn & Co.
68. I, G Long: Wilderness Ways. Ginn & Co.
69. I, G Long: Secrets of the Woods. Ginn & Co.
70. I, G Long: Little Brother of the Bear. Ginn & Co.
71. I, G Long: School of the Woods. Ginn & Co.
72. I, G Long: Following the Deer. Ginn & Co.
73. All Eddy: Friends and Helpers. Ginn & Co.
74. All Seton: Lobo, Rag, and Vixen. Scribners.
75. I, G Sharpe: Wild Life Near Home. Century Co.
76. P, I Wright: Birds and Beasts. Macmillan Co.
77. I, G Cornish: Animals at Work and at Play. Macmillan Co.
78. G Ingersoll: Wild Neighbors. Macmillan Co.
79. P, I Johonnot: Feathers and Fur. American Book Co.
80. P, I Johonnot: Claws and Hoofs. American Book Co.
81. P, I Johonnot: Neighbors with Wings and Fins. American Book Co.
82. All Seton: Krag and Johnny Bear. Scribners.
83. P, I Miller: Funny Friends. Dutton.
84. P, I Monteith: Living Creatures. American Book Co.
85. G French: Animal Activities. Longmans, Green & Co.
86. G Buckley: Life and Her Children. Appletons.
87. I, G Emerton: Life on the Seashore. Bates.
88. All Hardy: Hall of Shells. Ginn & Co.
89. All Hardy: Sea (Animal) Stories. Ginn & Co.
90. G Heilprin: Animal Life on the Seashore. Lippincott.
91. G Mayer: Seashore Life. Barnes.
92. Deane: The Wonders of the Sea and Shore. Lothrop.
93. G Furneaux: Life in Ponds and Streams. Longmans, Green & Co.
94. G What Mr. Darwin Saw. Harpers.

Birds

KEYS:

95. G Apgar: Birds of the United States. American Book Co.
96. G Bailey: Handbook of the Birds of the Western United States. Houghton, Mifflin & Co.

97. Baird, Brewer, Ridgeway: North American Birds. 3 vols. Little, Brown & Co.
98. All Blanchan: Bird Neighbors. Doubleday, Page & Co.
99. All Blanchan: Game Birds. Doubleday, Page & Co.
100. G Chapman: Handbook of the Birds of Eastern North America. Appletons.
101. G Chapman and Reed: Color Key to North American Birds. Appletons.
102. G Grant: Our Common Birds, and How to Know Them. Scribners.
103. G Reed: North American Birds' Eggs. Doubleday, Page & Co.
104. P, I Audubon Bird Chart. Prang Educational Co.
105. All Mumford: Bird Chart. (Colored.) Mountjoy.
106. G Wright: Bird Craft. Macmillan Co.

GENERAL:

107. Babcock: Bird Day. Silver, Burdette & Co.
108. I, G Baskett: Story of the Birds. Appletons.
109. I, G Blanchan: How to Attract the Birds. Doubleday, Page & Co.
110. I, G Eckstrom: The Woodpeckers. Houghton, Mifflin & Co.
111. I, G Dugmore: Bird Homes. Doubleday, Page & Co.
112. I, G Herrick: Home Life of Wild Birds. Putnams.
113. All Lange: Our Native Birds. (Protection.) Macmillan Co.
114. P, I Miller: First and Second Books of Birds. Houghton, Mifflin & Co.
115. All Merriam: Birds Through an Opera Glass. Houghton, Mifflin & Co.
116. All Merriam: Birds of Village and Field. Houghton, Mifflin & Co.
117. P, I Stickney: Bird World. Ginn & Co.
118. G Sanford, Bishop, VanDyke: The Waterfowl. Macmillan Co.
119. P, I Torrey: Everyday Birds. Houghton, Mifflin & Co.
120. G Weed and Dearborn: Birds in Relation to Man. Lippincott.
121. P Weed: Birdlife Stories. Rand, McNally & Co.
122. P, I Grinnell: Our Feathered Friends. D. C. Heath & Co.
123. P, I Miller: True Stories of Birdlife. Houghton, Mifflin & Co.
124. Finley: American Birds. Scribners.
125. G Beebe: The Bird. H. Holt & Co.

Insects

FOR IDENTIFICATION:

126. Comstock's Manual of Insects. Comstock Publishing Co.
127. I, G Holland: Butterfly Book. Doubleday, Page & Co.

128. G Holland: The Moth Book. Doubleday, Page & Co.
129. I, G Howard: The Insect Book. Doubleday, Page & Co.
130. G Kellogg: American Insects. H. Holt & Co.
130*a*. I, G Patterson: The Spinner Family. McClurg & Co.
131. I, G Emerton: Common Spiders. Ginn & Co.

GENERAL:

132. I, G Cragin: Our Insect Friends and Foes. Putnams.
133. I, G Comstock, A. B.: Keeping Bees. H. Holt & Co.
134. G Dickerson: Moths and Butterflies. Ginn & Co.
135. G Howard: Mosquitoes. McClure, Phillips & Co.
136. I, G Hunter: Elementary Studies in Insect Life. Crane & Co.
137. G Hyatt and Arms: Insecta. D. C. Heath & Co.
138. G Maeterlinck: The Life of the Bee. Dodd, Mead & Co.
139. G Ballard: Among Moths and Butterflies. Putnams.
140. P, I Doulton: Wings and Stings. Rand, McNally.
141. P, I Morley: Butterflies and Bees. Ginn & Co.
142. P Mulets: Story of Insects. (Phyllis Books.) Page.
143. P, I Morley: Insect Folk. Ginn & Co.
144. I, G Morley: The Honey Makers. McClurg & Co.
145. I, G Morley: The Bee People. McClurg & Co.
146. I, G Morley: Wasps and Their Ways. McClurg & Co.
147. I, G Noel: Buzz. H. Holt & Co.
148. G Smith: Economic Entomology. Lippincott.
148*a*. Folsom: Economic Entomology. P. Blakiston & Co.
149. I, G Soule and Eliott: Caterpillars and Their Moths. Century Co.
150. G Weed: Nature Biographies. Doubleday, Page & Co.
151. G Weed: Life Histories of American Insects. Macmillan Co.

Botany

TEXT-BOOKS AND NATURAL HISTORIES:

152. All Andrews: Botany All the Year Round. American Book Co.
153. I, G Atkinson: College Botany. H. Holt & Co.
154. I, G Bailey: Lessons with Plants. Macmillan Co.
155. I, G Bailey: Botany. Macmillan Co.
156. G Bergen and Davis: Principles of Botany. Ginn & Co.
157. I, G Bergen: Outlines of Botany. Ginn & Co.
158. I, G Coulter: Plant Relations. Appletons.
159. I, G Coulter: Plant Structures. Appletons.
160. I, G Coulter: Plants. Appletons.
161. All Kerner and Oliver: Natural History of Plants. H. Holt & Co.

162. I, G Leavitt: Outlines of Botany. American Book Co.
163. All Gray: Lessons in Botany. American Book Co.
164. I, G McDougal: The Nature and Work of Plants. Macmillan Co.
165. I, G Osterhout: Experiments with Plants. Macmillan Co.
166. I, G Stevens. Botany. D. C. Heath & Co.

KEYS AND BOOKS FOR IDENTIFICATION:

167. G Atkinson: Edible and Poisonous Mushrooms. Plant Publishing Co.
168. All Blanchan: Nature's Garden. Doubleday, Page & Co.
169. All Britton and Brown: Illustrated Flora. Scribners.
170. All Gray: Manual. American Book Co.
171. All Gray: Field, Forest, and Garden Botany. American Book Co.
172. I, G Clute: Our Native Ferns in Their Native Haunts. Stokes.
173. All Keeler: Our Native Trees. Scribners.
174. All Lounsberry: Guide to the Trees. Stokes.
175. All Lounsberry: Guide to the Wild Flowers. Stokes.
176. All Mathews: Familiar Flowers of Field and Garden. Appletons.
177. All Mathews: Familiar Trees. Appletons.
178. All McFarland: Getting Acquainted with the Trees. Outlook Co.
179. I, G Parsons: How to Know the Ferns. Scribners.
180. I, G Marshall: The Mushroom Book. Doubleday, Page & Co.
181. G Underwood: Our Native Ferns. H. Holt & Co.
182. G Sargent: Manual of Trees. Houghton, Mifflin & Co.
183. All Creevy: Flowers of Field, etc. Harpers.
184. All Going: Field, Forest, and Wayside Flowers. Baker, Taylor & Co.
185. All Keeler: Native Shrubs. Scribners.
186. I, G Peterson: How to Know the Wild Fruits. Macmillan Co.
187. I, G Wright: Flowers and Ferns. Macmillan Co.
188 I, G Dana: How to Know the Wild Flowers. Scribners.
189. I, G Parkhurst: Trees, Shrubs, and Vines of the Nor. East. U. S. Scribners.

General Botany

190. All Atkinson: First Studies of Plant Life. Ginn & Co.
191. All Beal: Seed Dispersal. Ginn & Co.
192. I, G Bailey: Talks Afield. Houghton, Mifflin & Co.
193. All Dana: Plants and Their Children. American Book Co.
194. G Geddes: Chapters in Modern Botany. Scribners.

195. I, G Herrick: Chapters in Plant Life. American Book Co.
196. I, G McDougal: Elementary Plant Physiology. Longmans.
197. P, I Morley: A Few Familiar Flowers. Ginn & Co.
198. P, I Morley: Little Wanderers. Ginn & Co.
199. G Newman: Bacteria. Putnams.
200. P, I Morley: Flowers and their Friends. Ginn & Co.
201. P, I Morley: Seed Babies. Ginn & Co.
202. P, I Weed: Seed Travellers. Ginn & Co.
203. All Newell's Outlines of Botany. (2 vols.) Ginn & Co.
204. P Mulets: Story of Trees. Phyllis Books.) Page.
205. P Mulets: Flower Story. (Phyllis Books.) Page.
206. P, I Cooper: Short Stories in Botany for Young Children. Crowell.
207. G Gibson: Blossom Hosts and Insect Guests. Newson.
208. Conn: Story of Germ Life. Appletons.
209. G Conn: Bacteria, Yeast, and Moulds in the Home. Ginn & Co.
210. G Harwood: New Plant Creations. (Luther Burbank.)
211. I, G Vincent: The Plant World. Appletons.
212. I, G MacDougal: Living Plants. Baker, Taylor & Co.
213. I, G Sargent: Corn Plants. Houghton, Mifflin & Co.
214. All Stone and Pickett: Trees in Prose and Poetry. Ginn & Co.
215. I, G Weed: Ten New England Blossoms. Houghton, Mifflin & Co.
216. G Flagg: A Year with Trees. Educational Publishing Co.

FORESTRY:

217. G Bruncken: North American Forests and Forestry. Putnams.
218. G Gifford: Practical Forestry. Appletons.
219. G Pinchot: Primer of Forestry. United States Department of Agriculture.
220. G Roth: First Book in Forestry. Ginn & Co.
220*a* G Green: Forestry in Minnesota. Minnesota Natural History Survey.

Agriculture and Gardening

221. All Bailey: Garden Making. Macmillan Co.
222. All Hatch and Hazlewood: Elementary Agriculture. Row, Peterson & Co.
223. I, G Burkett, Stevens, and Hill: Agriculture for Beginners. Ginn & Co.
224. Shelton: The Seasons in a Flower Garden. Scribners.
225. I, G Edgar: The Story of a Grain of Wheat. Appletons.
226. I, G Eggert: Professional Farming. Welch & Co.

227. I, G Goodrich: First Book in Farming. Doubleday, Page & Co.
228. I, G Goff and Mayne: First Principles of Agriculture. American Book Co.
229. All Hunn and Bailey: The Practical Garden Book. Macmillan Co.
230. I, G Percival: Agricultural Botany. H. Holt & Co.
231. I, G Bailey: Principles of Agriculture. Macmillan Co.
232. I, G Bailey: Nursery Book. Macmillan Co.
233. G Bailey: Plant Breeding. Macmillan Co.
234. P Brown: Outline of School Gardening. Hyannis Normal School.
235. All Allen and Godfrey: Miniature Window Gardening. Pott & Co.
236. I, G Barnard: Talks about Useful Plants. Funk, Wagnalls Co.
237. P, I Duncan: Mary's Garden and How it Grew. Century Co.
238. I, G Powell: The Orchard and Fruit Garden. McClure, Phillips & Co.
239. G Morris: Farming for Boys. Houghton, Mifflin & Co.
240. All Hemenway: How to Make a School Garden. Doubleday, Page & Co.
241. I, G James: Practical Agriculture. Appletons.
242. G King: The Soil. Macmillan & Co.
243. G King: The Physics of Agriculture. Published by the Author.
244. P, I Shepard: Life on the Farm. Flanagan.
245. All Skinner: Little Gardens. Appletons.
246. I, G Publications of the United States Department of Agriculture:

Many of these are of very great value in teaching nature-study. They consist of Year-books upon general topics in agriculture, special Bulletins on certain crops, methods, etc., and numerous Farmers' Bulletins. They are upon many practical household, farmyard, and field topics. Send for a list of the Farmers' Bulletins. The Year-books may sometimes be obtained free through the courtesy of the local Representative in Congress, or they may be bought from the Superintendent of Documents, Government Printing Office, Washington, D. C. Send also for the General list of publications of the Department of Agriculture, in which many Bulletins will be found upon crops, economic entomology, soils, economic ornithology, bird protection, trees, forestry, etc. These Bulletins are generally not distributed gratis, but are well worth buying.

The following is a list of the Farmers' Bulletins available for distribution January, 1907, and useful in nature-study, sent free to any address in the United States on application to a Senator, Representative or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C.

(22) The Feeding of Farm Animals.
(25) Peanuts: Culture and Uses.

(27) Flax for Seed and Fibre.
(28) Weeds: And How to Kill Them.
(29) Souring and Other Changes in Milk.
(32) Silos and Silage.
(33) Peach Growing for Market.
(34) Meats: Composition and Cooking.
(35) Potato Culture.
(39) Onion Culture.
(41) Fowls: Care and Feeding.
(42) Facts About Milk.
(44) Commercial Fertilizers.
(49) Sheep Feeding.
(51) Standard Varieties of Chickens.
(52) The Sugar Beet.
(54) Some Common Birds.
(55) The Dairy Herd.
(59) Bee Keeping.
(61) Asparagus Culture.
(62) Marketing Farm Produce.
(64) Ducks and Geese.
(66) Meadows and Pastures.
(71) Essentials in Beef Production.
(74) Milk as Food.
(77) The Liming of Soils.
(80) The Peach Twig-borer.
(85) Fish as Food.
(86) Thirty Poisonous Plants.
(88) Alkali Lands.
(93) Sugar as Food.
(95) Good Roads for Farmers.
(96) Raising Sheep for Mutton.
(99) Insect Enemies of Shade Trees.
(104) Notes on Frost.
(106) Breeds of Dairy Cattle.
(110) Rice Culture in the United States.
(111) Farmers' Interest in Good Seed.
(112) Bread and Bread Making.
(113) The Apple and How to Grow It.
(121) Beans, Peas, and other Legumes as Food.
(126) Practical Suggestions for Farm Buildings.
(127) Important Insecticides.
(128) Eggs and Their Uses as Food.
(129) Sweet Potatoes.
(132) Insect Enemies of Growing Wheat.

(134) Tree Planting in Rural School Grounds.
(135) Sorghum Sirup Manufacture.
(137) The Angora Goat.
(138) Irrigation in Field and Garden.
(140) Pineapple Growing.
(141) Poultry Raising on the Farm.
(143) The Conformation of Beef and Dairy Cattle.
(146) Insecticides and Fungicides.
(148) Celery Culture.
(154) The Home Fruit Garden: Preparation and Care.
(155) How Insects Affect Health in Rural Districts.
(156) The Home Vineyard.
(157) The Propagation of Plants.
(161) Practical Suggestions for Fruit Growers.
(165) Culture of the Silkworm.
(166) Cheese Making on the Farm.
(170) Principles of Horse Feeding.
(172) Scale Insects and Mites on Citrus Trees.
(173) Primer of Forestry.
(175) Home Manufacture and Use of Unfermented Grape Juice.
(176) Cranberry Culture.
(177) Squab Raising.
(179) Horseshoeing.
(181) Pruning.
(182) Poultry as Food.
(183) Meat on the Farm: Butchering, Curing, and Keeping.
(184) Marketing Live Stock.
(185) Beautifying the Home Grounds.
(187) Drainage of Farm Lands.
(192) Barnyard Manure.
(195) Annual Flowering Plants.
(196) Usefulness of the American Toad.
(198) Strawberries.
(199) Corn Growing.
(200) Turkeys.
(201) Cream Separator on Western Farms.
(203) Canned Fruits, Preserves, and Jellies.
(204) The Cultivation of Mushrooms.
(205) Pig Management.
(208) Varieties of Fruits Recommended for Planting.
(213) Raspberries.
(215) Alfalfa Growing.
(218) The School Garden.
(219) Lessons from the Grain Rust Epidemic of 1904.

(220) Tomatoes.
(228) Forest Planting and Farm Management.
(229) The Production of Good Seed Corn.
(231) Spraying for Cucumber and Melon Diseases.
(234) The Guinea Fowl.
(235) Preparation of Cement Concrete.
(236) Incubation and Incubators.
(240) Inoculation of Legumes.
(241) Butter Making on the Farm.
(242) An Example of Model Farming.
(243) Fungicides and their Use in Preventing Diseases of Fruits.
(245) Renovation of Worn-out Soils.
(247) The Control of the Codling Moth and Apple Scab.
(248) The Lawn.
(252) Maple Sugar and Sirup.
(253) The Germination of Seed Corn.
(254) Cucumbers.
(255) The Home Vegetable Garden.
(257) Soil Fertility.
(260) Seed of Red Clover and Its Impurities.
(264) The Brown-tail Moth and How to Control It.
(265) Game Laws for 1906.
(266) Management of Soils to Conserve Moisture.
(268) Industrial Alcohol: Sources and Manufacture.
(269) Industrial Alcohol: Uses and Statistics.
246*a*. Publications of State Agricultural Schools. These are similar to the Government reports. Many may be had free. Send for list.

Physics

247. Aldous: Elementary Physics. Macmillan Co.
248. Atkinson-Ganot: Physics. Wm. Wood & Co.
249. G Atkinson: Electricity for Everybody. Century Co.
250. G Millikin and Gale: Physics. Ginn & Co.
250*a*. G Avery: School Physics. Sheldon & Co.
251. G Avery: First Book in Physical Science. Sheldon & Co.
252. G Benjamin: Age of Electricity. Scribners.
253. G Carhart and Chute: Physics. Allyn & Bacon.
254. G Gage: Physics. Ginn & Co.
255. G Harrington: Physics for Grammar Grades. American Book Co.
256. Jackson: Elementary Electricity and Magnetism. Macmillan Co.
257. G Mann and Twiss: Physics. Scott, Foresman & Co.

258. G Miller and Foerste: Physics. Scribners.
259. G Gifford: First Lessons in Physics. Thompson.
260. G Barnard: First Steps in Electricity. Maynard.
261. G St. John: Things a Boy Ought to Know About Electricity. St. John.

Chemistry

262. G Johnston: Chemistry of Common Life. Appletons.
263. G Linebarger: Chemistry. Rand, McNally & Co.
264. G Newell's Descriptive Chemistry. D. C. Heath & Co.
265. Newth: Inorganic Chemistry. Longmans, Green & Co.
266. Remsen: Chemistry. H. Holt & Co.
267. G Snyder: Chemistry of Plant and Animal Life. Macmillan Co.
268. G Williams: Chemistry of Cookery. Appletons.
269. G Williams: Chemistry. Ginn & Co.
270. G Avery: School Chemistry. American Book Co.
271. G Ballard: The World of Matter.
272. G Hessler and Smith: Chemistry. Sanborn.
273. G Newth: Elementary Chemistry. Longmans, Green & Co.
274. G Richards and Elliott: The Chemistry of Cooking and Cleaning. Home Science Publishing Co.
275. G Black: Photography Indoors and Out. Houghton, Mifflin Co.

Manuals of Construction for Boys.—Invention.

276. I, G Barnard: Tools and Machines. Silver, Burdette & Co.
277. I, G Modern Boy's Playmate. Warne.
278. I, G Waite: A Boys' Workshop. Lothrop.
279. I, G Wheeler: Woodworking. Putnams.
280. I, G Bond: The Scientific American Boy. Munn.
281. I, G Hopkins: Home Mechanics. Munn.
282. I, G Hopkins: Experimental Science. Munn.
283. I, G Magical Experiments, Science and Play: McKay.
284. I, G Thurston: History of the Steam Engine. Appletons.
285. I, G Doubleday: Stories of Inventors. Doubleday, Page & Co.
286. I, G Cochrane: Modern Industrial Progress. Lippincott.
287. I, G Cochrane: Romance of Industry and Invention. Chambers.
288. I, G Macon: Origin of Inventions. Scribners.
289. I, G Sutherland: Twentieth Century Inventions. Longmans, Green & Co.
290. I, G Byrn: Progress of Inventions in the Nineteenth Century.

291. I, G Baker: Boys' Book of Inventions. McClurg & Co.
292. I, G Baker: Municipal Engineering and Sanitation.
293. I, G Williams: Romance of Modern Invention. Lippincott.
294. I, G Williams: Romance of Modern Engineering. Lippincott.
295. I, G Beard: Field and Forest Handy Book. Scribners.
296. I, G Beard: The American Boy's Handy Book. Scribners.
297. I, G Beard: The American Boy's Book of Sports. Scribners.
298. I, G Beard: The Jack of All Trades. Scribners.
299. I, G Keene: Boys' Guide to Fishing, etc. Lee & Shepard.
300. I, G Thompson: The Boys' Book of Sports and Outdoor Life. Century Co.

Books for Girls.—Domestic Economy

301. P Lucas: What Shall We Do Now? Stokes.
302. P White: The Child's Rainy Day Book. Doubleday, Page & Co.
303. I, G Williams and Fisher: Elements of Cookery.
304. I, G Wilson: Domestic Science in Grammar Grades. Macmillan Co.
305. I, G Beard: American Girl's Handy Book. Scribners.
306. I, G Beard: Indoor and Outdoor Handicraft. Scribners.
307. I, G Beard: What a Girl Can Make and Do. Scribners.
308. I, G Campbell: American Girl's Home Book of Work and Play. Putnams.
309. I, G Kirkland: Dora's Housekeeping. McClurg & Co.
310. I, G Kirkland: Six Little Cooks. McClurg & Co.
311. I, G Tate: The Child's Cookery Book. Richards.

Industry

311*a*. All Carpenter: Foods and Their Uses. Scribners.
312. P, I Chamberlain: How We are Clothed. Macmillan Co.
313. P, I Chamberlain: How We are Fed. Macmillan Co.
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